National Skills Standard for

Cleanroom Readiness

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1. Skill cluster description

This skill cluster addresses the skills and knowledge required of individuals who work inside cleanroom environments at the operational/frontline level. These individuals work in bio-manufacturing, including automatic, semi-automatic and traditional (manual) aseptic manufacturing processes. An individual in this role should be able to perform well in a highly structured and disciplined environment.

This skill cluster includes contamination control and the preparation for, the physical behaviour/etiquette required, and the work procedures required for cleanrooms, including handling of materials, waste disposal, documentation, considerations for equipment operation and workplace safety measures for cleanrooms. This skill cluster focuses on ISO Classes 5-8/EU GMP Grades A-D, which are the types of cleanroom environments typical of bio-manufacturing.

While cleanroom standards and levels required depend on the type of product being produced and the processes used to manufacture the specified product, this skill cluster focuses on the foundational skills and knowledge that are typical and common across many processes and products.

Sample occupational titles for individuals who apply this skill cluster in their day-to-day work include Production Technician, Production Technologist, Production Worker, Machine Operator, Manufacturing Associate, Manufacturing Operator, Pharmaceutical Processor, Manufacturing Material Handler, Packaging Production Technician, and Compounder.

This skill cluster *does not* include individuals who work in areas outside of production, such as those involved in shipping/receiving raw materials/end products, administration, quality assurance, facility and cleanroom cleaning and sanitation. While these individuals may conduct some of their work in a cleanroom and use specialized cleanroom tools, they are not the focus of this skill cluster.

1.1 Education and professional experience

An individual in this role must have a minimum of a high school diploma with a preference for a technical diploma or Bachelor of Science with hands-on GMP experience.

2. National skill cluster

2.1 Skills category: Cleanroom protocols table

Skills Category: Cleanroom protocols

Major skill	Competency
A Prepare to work in cleanroom	1. Follow personal conduct and hygiene protocols 2. Follow aseptic gowning procedures and enter cleanroom
B Work in cleanroom	3. Behave appropriately in cleanroom 4. Operate production equipment in cleanroom 5. Work in biosafety cabinet (BSC) 6. Use pipette in cleanroom environment 7. Use manual equipment and tools in cleanroom environment 8. Control materials and supplies for work in cleanroom 9. Follow environmental monitoring requirements 10. Monitor integrity of product 11. Follow cleanroom waste management procedures 12. Follow cleanroom documentation procedures
C Follow cleanroom exit and de-gowning procedures	13. Follow cleanroom exit and de-gowning procedures
D Comply with workplace safety procedures for cleanrooms	14. Follow workplace safety procedures for cleanroom 15. Respond to emergencies in cleanroom

2.2 Cleanroom protocols major skills and competencies

2.2.1 Prepare to work in a cleanroom

2.2.1.1 Follow personal conduct and hygiene protocols

2.2.1.1.1 Purpose

Human skin is the largest source of contamination in aseptic manufacturing processes. The average person sheds more than 30,000 skin cells per minute. Contaminated environments can lead to product recalls, regulatory observations, fines, or consumer death. The most effective means of preventing contamination from entering the cleanroom environment is following personal conduct and hygiene protocols.

2.2.1.1.2 Performance

Competent technologists/technicians must:

P1. Report any signs of illness or conditions that may affect the integrity of aseptic processing to the supervisor, e.g., fever, sunburn, eczema, skin rash, cough, allergic reaction, open wound, recent tattoo, communicable disease

P2. Maintain good personal hygiene, including regular hand washing and taking regular bath/shower

P3. Keep natural fingernails short

P4. Not smoke or vape within 45 minutes of entering a cleanroom

P5. Not wear:

- artificial nails or nail tips
- eyelash enhancements
- outer garments and items, e.g., coats, hats, jackets, vests, sweaters, scarves, bandanas, and sunglasses, except for approved religious garments and items
- any accessories, e.g., watch, wrist, neck and/or head jewelry
- fabrics that shed, e.g., wool
- open-toed shoes

P6. Not use:

- leave-in hair products, e.g., hairspray, dry shampoo, mousse, gel
- facial make-up except for non-tinted and non-scented skin and lip moisturizers
- scented products, including perfume and cologne

P7. Seek permission from the supervisor to wear medical items and devices such as eyeglasses, hearing aids and medical information jewelry:

- clean and disinfect approved items before entering the gowning area

P8. Wear acceptable personal garments that are clean, non-frayed and non-linting

P9. Store all personal items and consumables (e.g. cell phones, earbuds, food, lozenges) in designated areas

P10. Complete hand hygiene protocols, including:

- clean and remove debris from fingernails
- wash hands
- rinse soap with water flowing away from hands
- dry hands and arms using a clean low-lint towel or a designated automatic dryer
- use alcohol-based hand rub (ABHR), immersing fingertips for several seconds
- cover opposite hand and wrist/forearm with ABHR/sanitizer until it fully evaporates, at least 15 seconds

2.2.1.1.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs), e.g. process for storing personal items

K2. Occupational Health and Safety standard requirements

K3. Grades of cleanrooms as defined in GUI-0119 Annex 1 to the Good Manufacturing Practices Guide – Manufacture of sterile drugs

K4. ISO Clean Room Classifications and how they compare to the Grades defined in GUI-0119

K5. Personnel hygiene regulatory requirements as defined in GUI-0119

K6. Importance of personal conduct and hygiene to cleanroom work and consequences of non-compliance

K7. Types of contamination, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

2.2.1.1.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Types of products and bio-manufacturing processes

V3. Site-specific rules

2.2.1.1.5 Glossary

- ***Clean:*** *to physically remove dirt and debris*
- ***Disinfect:*** *to kill bacteria and viruses on surfaces*

2.2.1.2 Follow aseptic gowning procedures and enter the cleanroom

2.2.1.2.1 Purpose

Gowning reduces contamination risks associated with the entry of personnel into the cleanroom by eliminating or containing any sources of contamination present on the individual. Correctly fitting and using protective gowning materials is critical to maintaining the integrity of the cleanroom and the product.

Note: This competency is set to teach/assess individuals at a high level to ensure they can perform at this level. If they can do this, they should be able to perform a less stringent gowning procedure as well. The order of gowning may vary depending on the manufacturing facility. The order below is common or typical and is presented for training purposes.

2.2.1.2.2 Performance

Competent technologists/technicians must:

P1. Be qualified to gown by organization

P2. Follow access control protocols, e.g., receive evaluation and permission before proceeding between areas, use key card

P3. Use doors and transfer areas correctly to enter each area:

- ensure the area to be entered does not have too many people present already, i.e. has not exceeded maximum occupancy for the area
- verify correct reading of devices that indicate airflow immediately before entry, as required
- allow the entry door to close and a predetermined period to pass before moving to the next open door in the transfer area
- do not leave doors open
- do not open and close doors quickly

P4. Sanitize hands

P5. Put on cleanroom underclothing/scrubs, as required

P6. Put on a hairnet, bouffant and/or beard cover, ensuring all hair is contained

P7. Put on overshoes/shoe covers, as required

P8. Choose appropriate gowning materials for work being performed, visually inspecting to:
- ensure gowning materials are not expired, as required
- evaluate packaging/materials for compromises before using

P9. Put on gowning gloves and sanitize them, as required, to handle cleanroom gowning materials

P10. Sanitize the bench as required

P11. Sanitize gowning materials packaging

P12. Remove gowning gloves, as required

P13. Put on sterile gloves, touching only the inside:
- never touch exposed skin with a gloved hand

P14. Sanitize sterile gloves after donning each item, as required

P15. Don mask ensuring tight fit

P16. Don hood, as required, ensuring a tight fit and correct neck seal

P17. Don sterile-processed coveralls (‘jumpsuit’/‘bunny suit’) without touching the floor, clothes, or bench:
- touch only the inside of the jumpsuit
- tuck in the hood, as required
- put on the belt, as required
- fasten any neck, ankle and sleeve adjustments and closures, touching only zipper/tabs/snaps
- attach other items to the belt, as required, e.g., battery pack, filter unit

P18. Put on booties:
- tuck jumpsuit into booties
- sit on the ‘dirty’ side of the bench
- put on one bootie
- swing bootied foot to ‘clean’ side of the bench

- put on other bootie on the ‘dirty’ side of the bench
- swing other bootied foot to ‘clean’ side of the bench

P19. Put on sterile goggles and/or helmet, as required

P20. Put on second sterile gloves over the first pair, ensuring cuffs are over the sleeves

P21. Perform final self-inspection in the mirror before entry into the cleanroom:

- evaluate the fit of items, i.e., ensure no gaps, ensure no hair visible

2.2.1.2.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs)

K2. Occupational Health and Safety standard requirements

K3. Grades of cleanrooms as defined in GUI-0119 Annex 1 to the Good Manufacturing Practices Guide – Manufacture of sterile drugs and gowning requirements for each

K4. ISO Clean Room Classifications and how they compare to the Grades defined in GUI-0119

K5. Gowning and entry requirements as defined by the Canadian Biosafety Standard, i.e., '4.4 Entry and Exit'

K6. Gowning and entry requirements as defined in GUI-0119, i.e., 'Personnel', including gowning materials required for each Grade

K7. Importance of following correct gowning procedures and consequences of non-compliance

K8. Gowning and entry requirements when moving from one Class/Grade environment to another, e.g., moving from Class D to Class C

K9. Types of contamination, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K10. Protection is provided by gowning materials for personnel, products and environment

K11. Aseptic gown certification program in use at the facility

K12. Distinction between single-use and reusable gowning materials

K13. Distinction between sterile and non-sterile surfaces of gowning materials

K14. Differential pressure within cleanroom spaces, including how it is maintained and used to aid in contamination control

K15. Access control protocols

2.2.1.2.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Sizes and types of gowning materials

V3. Reusable and single-use items

V4. Types of products and bio-manufacturing processes

V5. Site-specific rules

V6. Approved religious attire and items, e.g. if wearing hijab may not require hairnet

2.2.1.2.5 Glossary

- ***Bunny suit:*** *protective clothing worn by an individual in a cleanroom that keeps human bacteria from contaminating the bio-manufacturing*

2.2.2 Work in a cleanroom

2.2.2.1 Behave appropriately in the cleanroom

2.2.2.1.1 Purpose

Humans are the greatest source of contamination in aseptic manufacturing processes. Contaminated environments can lead to product recalls, regulatory observations, fines, or consumer death. Correctly monitoring one's behaviour, posture, physical movement, hygiene, and gown standards in a cleanroom helps maintain the manufacturing environment's sterility.

2.2.2.1.2 Performance

Competent technologists/technicians must:

P1. Review production work plans prior to working in the cleanroom

P2. Ensure own body position is not disrupting clean air supply and product/process surface, i.e., air supply (first air) to exposed product to own body position/personnel, then to general cleanroom area and then to air return/exhaust

P3. Hold equipment, materials, and products away from own body and other objects

P4. Avoid compromising the cleanroom environment, including must not:

- lean on surfaces, e.g., counters, walls, tabletops, rack
- allow hands to touch anything not directly related to production, including other people
- pick up items that fall to the floor:
  - if the item poses a safety hazard, use your feet to move the item to a safe location
- scratch, touch, or wipe your own skin areas
- allow items to come in contact with their own mucous membranes, e.g., mouth pipetting, drinking, inserting or removing contact lenses, blowing nose
- disrupt first-air
- talk when working close to the product
- smell or taste any chemical, vapour, or gas
- linger close to other people

P5. Move deliberately within the cleanroom:

- avoid sudden and rapid walking and movement which disrupts airflow causing turbulence

P6. Monitor gowning materials for any compromises while working, e.g., loose closures, rips, tears, wet:

- do not compromise the fit of materials
- periodically sanitize gloves

P7. Monitor your levels of fatigue:

- report to supervisor when own fatigue level is too high

P8. Exit and change gowning materials:

- after the prescribed time frame, as required
- when moving to higher classes or grades of cleanrooms

P9. Correct coworker's incorrect behaviour if the deviation is minor and when necessary:

- escalate the issue to the supervisor for major deviations

P10. Report your own and others' deviations

P11. Keep all areas within the cleanroom tidy

2.2.2.1.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs)

K2. Occupational Health and Safety standard requirements

K3. Importance of following correct cleanroom behaviour and consequences of non-compliance

K4. Grades of cleanrooms as defined in GUI-0119 Annex 1 to the Good Manufacturing Practices Guide – Manufacture of sterile drugs

K5. ISO Clean Room Classifications and how they compare to the Grades defined in GUI-0119

K6. Behaviour requirements as defined by the Canadian Biosafety Standard, i.e., '4.5 Work practices'

K7. Personnel requirements as defined in GUI-0119, including gowning attire required for each Grade

K8. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K9. Cross-contamination and how it occurs in a cleanroom

K10. Protection provided by gowning materials, e.g., how gowns/ 'bunny suits' protect products from human-caused contamination

K11. Importance of airflow within a cleanroom, including the concept of 'laminar flow' and principles of 'first air'

K12. How cleanroom airflow is impacted by human movement and posture

K13. Importance of reporting deviations

2.2.2.1.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Level of automation

V3. Types of products and bio-manufacturing processes

V4. Site-specific rules

2.2.2.1.5 Glossary

- ***Bunny suit**: protective clothing (cleanroom suit or coverall) worn by an individual in a cleanroom that keeps human bacteria from contaminating the bio-manufacturing process*
- ***First air:** undisrupted air coming directly from a HEPA filtration source*
- ***Laminar flow:** airflow in which the entire body of air within a designated space is uniform in both velocity and direction*

2.2.2.2 Operate production equipment in cleanroom

2.2.2.2.1 Purpose

Operating production equipment in a cleanroom requires close monitoring to ensure that the operation of the equipment during the production process does not affect the cleanroom environment. Cleanroom equipment may include isolators, restricted access barrier systems (RABs), bioreactors, incubators, aseptic filling equipment, peristaltic pumps, tube sealers and centrifuges, among others. Incorrect equipment operation can result in product loss, and contamination of the product and the cleanroom environment. This can cause costly product and ingredient loss and/or require additional equipment and cleanroom systems repair, maintenance and sanitation.

2.2.2.2.2 Performance

Competent technologists/technicians must:

P1. Review the production plan for the workday

P2. Use required Personal Protective Equipment (PPE) required for the production process and product, e.g., goggles, face shield, double gloves, respirator

P3. Wipe down equipment surfaces using designated lint-free wipes

P4. Verify if the equipment has been cleaned and disinfected, e.g., check documentation

P5. Verify equipment has been calibrated if required

P6. Start production equipment:
- input required operating settings, cycles and/or schedules as required

P7. Monitor process for any deviation that could impact the cleanroom environment/product quality and compliance process:
- respond to equipment alarms, as required
- make adjustments to operating parameters to correct nonconformances, if approved to do so
- document deviations and actions taken immediately

P8. Monitor the physical condition of equipment during operations, for example:
- leaks, e.g., air, gas, steam, product, liquid, moisture, etc.
- unusual changes in operating temperature
- control response times

P9. Check the integrity of seals and equipment components, e.g., isolator gloves

P10. Report any issues with equipment integrity immediately

P11. Take samples and/or conduct in-process tests at specified times using specified equipment and procedures

P12. Use contamination detection systems for process and product, if applicable

P13. Document equipment operation and complete traceability documentation for the product, as required:

- reference traceability and inventory control numbers for equipment used

2.2.2.2.3 Knowledge

Competent technologists/technicians must know:

K1. Equipment sanitation and operation as defined in the Government of Canada Manufacturing Practices Guide for Drug Products (GUI 0001) Equipment C.02.005: 2-5

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K5. Engineering controls for cleanroom, e.g., HEPA filtration

K6. Equipment cleaning and disinfection process, including preparation and selection of appropriate chemicals

K7. Production methods, e.g., batch, continuous

K8. Production processes, e.g., weighing and dispensing raw materials, compounding, filtration, dry granulation, milling, extrusion, drying, encapsulation, micronization, lyophilization, fill and finish, etc.

K9. Production equipment's purpose

K10. Production equipment's operating parameters and limits

K11. Potential impact of equipment operation on cleanroom environment

K12. Documentation requirements for operating equipment in cleanroom

2.2.2.2.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Level of automation

V2. Types and models of production equipment

V3. Types of products and bio-manufacturing processes

V4. Types and formats of ingredients used in the process

V5. Site-specific rules

2.2.2.2.5 Glossary

- ***Lyophilization:*** *a freeze-drying process that removes water by placing the frozen item under a vacuum that causes water to vapourize*
- ***Micronization:*** *the process of reducing particle sizes of pharmaceutical products to 1 micron or less under very high pressure, using shear, turbulence, acceleration and impact to make products more stable and clinically effective*

2.2.2.3 Work in a biosafety cabinet (BSC)

2.2.2.3.1 Purpose

Biosafety cabinets (BSCs) are used in traditional, manual pharmaceutical production work settings. They can provide a higher-level clean environment within a cleanroom. They protect the materials being worked on from contaminants and the production technologist/technician from exposure to biohazardous materials. It is very important to work carefully, slowly, and deliberately to prevent contamination of the BSC environment. Some BSC processes may require the assistance of another person. This assistant/coordinator may support the work of the technician/technologist in a large BSC or may coordinate the work of the technician/technologist and complete real-time documentation. A lack of attention to the steps required to work in a BSC can lead to costly production losses, potential risks to the technologist/technician and loss of production time.

2.2.2.3.2 Performance

Competent technologists/technicians must:

P1. Review production work plan before working in BSC

P2. Be qualified to work in BSC by organization

P3. Use required Personal Protective Equipment (PPE) required for the production process and product, e.g., gown, goggles, double gloves

P4. Prepare BSC for production:

- check that the certification sticker is current and BSC is within the calibration due date
- turn on BSC fans/blowers for the required time to purge any particulates
- clean and disinfect the inside of BSC using an approved cleaning system, using a cleaning agent for correct contact time
- gather cleanroom-approved required materials, supplies and equipment
- load materials inside BSC without disrupting first air
- organize materials according to the workflow that facilitates unidirectional flow
- ensure no obstruction of clean air coming from HEPA filters and objects placed at an appropriate distance
- connect aspirator bottles with approved disinfectant to vacuum system and online HEPA filter or approved collection system for liquid waste, as required
- set the height of the sash
- position and adjust the height of the approved footrest, as required

P5. Start up BSC system:

- ensure any filters within the BSC are in place and clean, e.g., HEPA in-line filters
- ensure gauges and indicators are displaying appropriate readings, as required
- turn on lights

P6. Assume the correct working position:

- ensure own face is above the window opening
- position armpits level and elbows appropriately

P7. Perform work in the center of the designated work surface:

- determine the sequence of tasks to minimize the frequency of movements and maximize efficiency:
    - organize work to occur from the ‘clean-side’ across the work surface to the ‘dirty side’ of the BSC space
- work slowly to prevent disruption of airflow within the BSC
- minimize material exposure to first air
- avoid cross-contamination
- do not touch sterile surfaces of materials, containers and equipment
- minimize activities that generate aerosols, e.g. tapping equipment on the edge of containers

P8. Perform handovers of work from inside BSC to other personnel outside of BSC, e.g., use a defined handover zone

P9. Monitor for changes in the BSC environment, i.e., regularly check the environmental monitoring system

P10. Monitor the integrity of PPE (e.g., gloves, sleeves, gowns) while working

P11. Document all deviations:

- describe the situation and any corrective action taken immediately
- ensure specified information is witnessed, as required

P12. Troubleshoot BSC alarms:

- respond to alarms within the scope of authority
- document correction
- determine the impact on the product
- report alarm and response to appropriate personnel, e.g., Quality Control

P13. Inform the supervisor immediately in the event of operational issues, spills, leaks or compromised BSC integrity

P14. In the event of a non-hazardous spill contained inside the BSC:

- remove hands slowly and change gloves and gown, then re-enter BSC workspace:
    - if the spill is on gloves, remove them inside BSC and leave them inside
- close all material containers
- use required towelling, detergents and disinfectants to clean up spills
- clean, disinfect and re-load materials and equipment, as required

P15. Shut down BSC after completing work:

- place hazardous disposables into appropriate containers (e.g., waste/sharps containers) before removing them from BSC
- run the BSC to purge airborne contaminants from the work area
- remove small equipment and hand tools from inside BSC

P16. Clean and disinfect BSC, e.g., manually wipe down inside BSC work area with approved detergent, run disinfectant system

P17. Document production:

- reference traceability and inventory control numbers for materials and equipment used, including for BSC

2.2.2.3.3 Knowledge

Competent technologists/technicians must know:

K1. Work in BSCs as defined by the Canadian Biosafety Standard, i.e., '3.6 Essential biosafety equipment 3.6.1,7 and 8

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K5. Importance of personal conduct and hygiene to cleanroom work and consequences of non-compliance

K6. Product traceability and inventory control systems

K7. Cleanroom environmental monitoring system audible and/or visual alerts

K8. Operating procedures for Class/Grade of BSC

K9. BSC alarm panel function and indicators, e.g., error codes

K10. Impact of background activities on cleanroom and BSC airflow, e.g., opening and closing of doors, personnel moving too quickly and too close to BSC

K11. Operating parameters of BSC, e.g., internal airflow, air filtration

K12. BSC cleaning system or cleaning requirements

K13. Documentation requirements for production, BSC function and operator actions

K14. Safety measures for internal BSC spills

2.2.2.3.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Level of automation

V2. Types of products and bio-manufacturing processes

V3. Types of materials and equipment being used in BSC

V4. Types and Classes/Grades of BSC being used for production

V5. Background cleanroom requirements

V6. Presence of hazardous materials

V7. Site-specific rules

2.2.2.3.5 Glossary

- ***Biosafety cabinet (BSC):*** *Also known as a Biological Safety Cabinet, a BSC is a partially enclosed workspace that creates an inflow and downflow of air, protecting the operator, environment, and product. It is mainly used for handling pathogenic biological samples or applications requiring a sterile work zone.*

2.2.2.4 Use a pipette in a cleanroom environment

2.2.2.4.1 Purpose

Pipettes transfer specified volumes of liquids from one container to another. This transfer can be used for a variety of purposes, including production and testing. Consistency in using pipettes is critical for ensuring products meet specifications. Incorrect use of pipettes can result in product contamination and/or a product that does not meet specifications. This can cause product and/or material loss and incorrect testing results.

2.2.2.4.2 Performance

Competent technologists/technicians must:

P1. Review production work plan for pipette work specifications, e.g., required transfer volumes, type of receiving containers

P2. Be qualified to use pipettes by the organization

P3. Use required Personal Protective Equipment (PPE), e.g., double gloves

P4. Select the correct type and size of the pipette (e.g., micropipette, serological pipette with pipette aid, repeater pipette) for the required volumes and task

P5. Gather supporting equipment, e.g., container/packages of the correct size and type of single-use pipettes/tips, discard the container

P6. Clean and disinfect pipette and supporting equipment and materials, as required

P7. Ensure calibration certification of the pipette is current

P8. Organize pipette and supporting equipment and materials in the workspace following a ‘clean’ to ‘dirty’ workflow

P9. Set uptake volume on the pipette, as required

P10. Fasten single-use pipette/tip, as required, for example:

- open the single-use tip container place the end of the pipette into the top end of the single-use tip, and push down to fasten the tip onto the end of the pipette
- peel the paper down to expose the top end of the disposable serological pipette and push it into the end of the pipette aid

P11. Transfer liquid using a pipette:

- pre-rinse pipette tip with liquid to improve accuracy, as required
- depress the pipette plunger to the required position/depth or use buttons on the pipette aid, if applicable
- maintain a tip immersion angle of 90° as much as possible
- withdraw liquid by placing the end of the single-use tip of the pipette just below the surface of the liquid to be transferred and slowly release the pipette plunger to draw up liquid into the pipette tip
- discharge liquid by positioning the pipette to the new container placing the tip against the side of the container, and slowly pushing on the pipette plunger to release liquid into the container to minimize generation of aerosol/spray and clean off drips
- maintain consistent speed and pressure to improve accuracy when performing multiple measurements
- do not touch the sterile inside of containers with any parts of the pipette that are not sterile
- discard the single-use tip by pushing the release button to place the tip into the tip discard container or remove the serological pipette from the pipette aid
- alert supervisor if the single-use component is used incorrectly, e.g., used to draw up a different material

P12. Use pipette in a controlled manner:

- move slowly and deliberately to prevent spills and tears, cuts, or rips in gloves
- lay down the micropipette or pipette aid gently onto to work surface when not in use to maintain calibration
- maintain sterility of single-use components

P13. Clean up pipette spills or liquid container spills:

- close all material containers
- use required towelling, detergents and disinfectants to clean up spills
- clean and disinfect equipment or replace materials as required

P14. Empty discard container in appropriate designated cleanroom waste receptacle, as required

P15. Complete job traveller/batch production record:

- document critical parameters, e.g. equipment calibration due dates, consumable expiry dates, and material hold times
- document any nonconformances

P16. Restock/notify the supervisor when supporting equipment and material supply levels are low

2.2.2.4.3 Knowledge

Competent technologists/technicians must know:

K1. Equipment sanitation and operation as defined in the Government of Canada Manufacturing Practices Guide for Drug Products (GUI 0001) Equipment C.02.005: 2-5

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K5. Types and sizes of pipettes and single-use components, e.g., tips, single-use serological pipettes

K6. Sterile and non-sterile sections of pipettes, components and containers

K7. Spill containment procedures

K8. Good documentation practices and documentation requirements for pipette work and product

2.2.2.4.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Make and models of pipettes being used, e.g., micropipette, serological pipettes with pipette aid, repeater pipette

V2. Types of products being transferred

V3. Purpose of transfer

V4. Site-specific rules

2.2.2.4.5 Glossary

- ***Single-use:*** *a disposable piece of equipment or item used once or for repeated tasks contacting the same material within a process step.*

2.2.2.5 Use manual equipment and tools in a cleanroom environment

2.2.2.5.1 Purpose

Benchtop equipment (e.g., scales, microscopes, microfuge, bead bath, vortex, pH meter, osmometer, etc.) and hand tools (e.g., spatulas, tubing, scissors, syringes, scalpels, pens, calculators, etc.) are used in cleanrooms for production. Some tools and equipment are part of the engineering controls for production work in a cleanroom or biosafety cabinet, such as equipment designed with single-use components. Incorrect selection of manual equipment and tools can result in product contamination, product and material loss, products that do not meet specifications, and incorrect testing results.

2.2.2.5.2 Performance

Competent technologists/technicians must:

P1. Review production work plan for types of equipment and equipment/tool number approved for use

P2. Use required Personal Protective Equipment (PPE), e.g., double gloves

P3. Obtain sanitized equipment and hand tools from pass-through or supply cart

P4. Place benchtop equipment and hand tools into work areas, e.g., isolators, restricted access barrier systems (RABs), or biosafety cabinets (BSCs)

P5. Organize equipment and hand tools in the workspace following a ‘clean’ to ‘dirty’ workflow

P6. Use benchtop equipment and hand tools:
- use for intended purpose only

- clean and disinfect benchtop equipment surfaces and hand tools between uses or as required/scheduled
- place hand tools in a designated location in the workspace to minimize movement and prevent dropping
- move slowly and deliberately to prevent spills and tears, cuts, or rips in gloves or gowning and disruption of airflow
- use and dispose of single-use components, as required
- use sharps (e.g., syringes with/without disposable needles, scissors, scalpels):
  - pick up and set down carefully to prevent tears, cuts, or rips in gloves
  - dispose of hazardous waste and disposable sharp components in the designated container

P7. Not pick up hand tools if they drop on the floor:

- do not reuse dropped tools unless they have been properly cleaned, sanitized, or sterilized

P8. Notify the supervisor when additional hand tools are required

P9. Document issues with benchtop equipment, as required:

- reference equipment and hand tool numbers used to perform work
- detail any deviations and actions taken

2.2.2.5.3 Knowledge

Competent technologists/technicians must know:

K1. Equipment cleaning, disinfection and operation as defined in the Government of Canada Manufacturing Practices Guide for Drug Products (GUI 0001) Equipment C.02.005: 2-5

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements, including de-energization and lock-out tag-out procedures

K4. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K5. Aseptic techniques that preserve the sterility of exposed products that are not in a closed system

K6. Importance of personal conduct and hygiene to cleanroom work and consequences of non-compliance

K7. Purpose of different benchtop equipment and hand tools

K8. Types and sizes of benchtop equipment and hand tools

K9. Disposal procedures for sharps, hazardous waste and single-use equipment components

K10. Spill containment procedures

K11. Accurate weighing and volume measurement practices

K12. Documentation requirements for work and product

2.2.2.5.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Size of manufacturing operation

V2. Make and models of benchtop equipment and hand tools being used

V3. Types of products and bio-manufacturing processes

2.2.2.5.5 Glossary

- ***Isolator:*** *a sealed workspace enclosure that completely separates the operator from the process area, which reduces contamination risk and is used for aseptic processes. The operator accesses the interior through glove ports or half suits. Isolators are typically equipped with a system for bio-decontamination. The process air handling unit (AHU) provides HEPA-filtered air to the interior in a unidirectional down-flow pattern. It can be set up to provide positive or negative air pressure.*
- ***Restricted access barrier system (RABS):*** *an enclosed workspace with a physical barrier between the processing area and the operator, which reduces contamination risk and is used for aseptic processes. Like isolators, the operator accesses the interior through glove ports or half suits. An air handler supplies HEPA-filtered, unidirectional airflow, providing an ISO 5 environment. Cleaning and decontamination are generally carried out manually.*

2.2.2.6 Control materials and supplies for work in the cleanroom

2.2.2.6.1 Purpose

The introduction of any raw materials/supplies and cleaning materials/supplies into a cleanroom requires planning to ensure the materials/supplies do not introduce undesired contaminants into the cleanroom. Materials/supplies must be handled carefully to maintain the sterility of the cleanroom environment. Inappropriate handling of materials/supplies can result in contaminated products, delays in production for additional cleaning and disinfection of the cleanroom, and extra costs to replace materials.

2.2.2.6.2 Performance

Competent technologists/technicians must:

P1. Review the production plan to determine the required materials, supplies and equipment needed to complete the required work:
- identify types and quantities of required materials, supplies and equipment, including types of waste containers
- only use cleanroom-approved materials, e.g., pens, paper, indelible ink
- follow organizational traceability and inventory control system requirements, e.g., equipment, material, part numbers, release authorization labels

P2. Use required Personal Protective Equipment (PPE), for work being performed within the cleanroom, e.g., gloves, goggles, face mask, respirator

P3. Transfer materials into the cleanroom:
- clean and disinfect exterior surfaces of materials and supplies to be used in the cleanroom or remove layer if in sterilized packaging
- use transfer points (e.g., cleanroom pass-throughs) or designated cleanroom carts for materials and supplies
- ensure unidirectional flow of materials
- ensure expiry dates on labels of all production and cleaning materials are acceptable
- ensure equipment calibration certification is up to date

P4. Place materials within the cleanroom:
- place materials in designated locations in the cleanroom
- clean and package materials/supplies correctly for transfer into isolators, restricted access barrier systems (RABS), or biosafety cabinets (BSCs)
- follow 5S principles, i.e. Sort, Set-in-order, Shine, Standardize, Sustain

P5. Prepare dilutions:
- calculate the volume of materials required based on the provided dilution ratios
- ensure containers used to receive transferred materials are clean and sterile
- decant liquids into clean and sterile containers
- label containers with transferred materials immediately after transfer:
  - do not use any unidentified liquids
  - provide information on contact/hold times, as required

P6. Use materials in designated locations only (e.g., biosafety cabinet) to control the risk of contamination to people, processes and the environment

P7. Keep all containers of material closed/sealed except when removing material for immediate use

P8. Perform line clearance:
- clean equipment or change out equipment between batches or production runs (line clearance/changeovers)
- remove all materials and equipment used for a specific product batch
- ensure spatial separation of materials and equipment used in different production processes and batches
- clean, disinfect and prepare the cleanroom for the next batch

P9. Prevent contamination, e.g., do not put material into an unsterilized container, do not combine the same materials of different lots or batches into one container

P10. Prevent cross-contamination, e.g., do not use the same tool for different materials, use single-use tool components as specified

P11. Transport materials using appropriate equipment and containers (e.g., cart, bucket or cooler) within the cleanroom

P12. Use transfer points (e.g., cleanroom pass-throughs) or designated cleanroom carts to move materials/supplies out of cleanroom

P13. Inform the supervisor immediately of unusual conditions, e.g., spill, leak, unknown or unlabelled materials

P14. Document materials, critical parameters and process outcomes:
- reference traceability and numbers for equipment/tools, materials, and consumables, as required
- throughput yields and defects
- detail any deviations, e.g. material contamination incidents and actions taken

2.2.2.6.3 Knowledge

Competent technologists/technicians must know:

K1. Materials handling as described in the Government of Canada Manufacturing Practices Guide for Drug Products (GUI 0001) C.02.011 Manufacturing Controls

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Workplace Hazardous Information System (WHMIS) and location of Safety Data Sheets (SDS)

K5. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K6. Product traceability and inventory control systems

K7. Types of materials being used for production, e.g., acids, bases, cryogens, flammables, combustibles, radioactives, compressed gases

K8. Properties of materials being used for production, e.g., toxicity, effects of contact, ingestion, exposure

K9. The “5S Principles” and how they are applied (i.e. Sort, Set-in-order, Shine, Standardize, Sustain)

K10. Exposure control plans for specific hazardous materials, e.g., biohazards

2.2.2.6.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Size of manufacturing facility

V2. Types of products and bio-manufacturing processes

V3. Types of materials used for production, e.g., acids, bases, cryogens, flammables, combustibles, radioactives, compressed gases

V4. Types of material packaging

V5. Site-specific rules

2.2.2.7 Follow environmental monitoring requirements

2.2.2.7.1 Purpose

Monitoring the cleanroom environment is critical to demonstrate that the cleanroom is performing to specific Class or Grade specifications required to manufacture products. Anyone working within a clean environment must know the operational parameter requirements for a clean and sterile working environment. Compromised cleanroom standards can cause product and material loss and production delays and affect time-sensitive materials.

2.2.2.7.2 Performance

Competent technologists/technicians must:

P1. Use required Personal Protective Equipment (PPE), e.g., gown, gloves

P2. Determine materials, equipment and consumables needed for environmental monitoring

P3. Keep cleanroom air returns and grills/vents clear:

- ensure equipment and materials do not block airflow or impede the laminar flow

P4. Notify the supervisor immediately of any unusual cleanroom system changes, for example:
- environmental monitoring system audible and/or visual alarms, e.g., tower lights
- changes in status
- changes in HVAC system operation
- unusual noises that may indicate leaks or malfunctions
- unusual odours

P5. Conduct active microbial monitoring, for example:
- use designated air samplers to take environmental particle readings at specified times in specified locations in the cleanroom, e.g., inside the biosafety cabinet (BSC)
- document readings:
  - ensure readings are witnessed, as required

P6. Conduct particulate (non-viable) monitoring:
- use designated particle counters to take environmental particle readings at specified times and locations inside the cleanroom, e.g. inside the BSC
- document readings
- ensure documented readings are witnessed, as required

P7. Conduct passive microbial monitoring, for example:
- place dishes of culture medium to collect airborne bacteria at specified locations in the cleanroom for the specified time for incubation and testing
- swab cleanroom surfaces for testing with the specified culture medium test dish or use contact plates to sample
- clean and disinfect surfaces after monitoring activities

P8. Conduct personnel monitoring of self, e.g. dab test, for example:
- take tests at specified times
- do not remove gloves or wash/wipe gloved hands or PPE before taking the test
- press fingertips or palm into specified, labelled sterile culture medium test dish
- change gloves after test
- ensure gloves that have been in contact with test media do not touch any other cleanroom surface

P9. Collect and submit test samples to quality control lab, as required

P10. Monitor for radiation, as required:

- wear and submit radiation monitoring devices for testing, e.g., personal radiation monitors

2.2.2.7.3 Knowledge

Competent technologists/technicians must know:

K1. Monitoring the cleanroom environment as described in GUI-0119 Annex 1 to the Good Manufacturing Practices guide – Manufacture of Sterile Drugs: Sterile Products, C.02.029 – Cleanroom and clean air device monitoring – 18; Personnel – 36.37, 41-45; Processing – 73-79, 81

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Different environmental control systems, e.g., HVAC, fan and air filtration systems, environmental sensor systems

K5. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K6. Importance of personal conduct and hygiene to cleanroom work and consequences of non-compliance

K7. 'At rest/static' and 'operational/dynamic' environmental monitoring

K8. Documentation requirements for cleanroom environmental monitoring

K9. Importance of uninterrupted airflow within a cleanroom, including the concept of 'laminar flow'

K10. How cleanroom airflow is impacted by human movement and posture

K11. Importance of reporting deviations

2.2.2.7.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Size of cleanroom

V3. Level of environmental monitor system automation

V4. Level of responsibility for environmental monitoring

V5. Number of workers in cleanroom

V6. Types of products and bio-manufacturing processes

V7. Site-specific rules

2.2.2.8 Monitor the integrity of the product

2.2.2.8.1 Purpose

It is critical to monitor the product at various stages of production to ensure that the final product meets the required specifications. Proactively identifying when the integrity of the product might be at risk saves an organization time, product, and materials and protects the organization against financial loss.

2.2.2.8.2 Performance

Competent technologists/technicians must:

P1. Use required Personal Protective Equipment (PPE), e.g., gown, gloves

P2. Monitor incoming materials and supplies:
- verify labels against batch record/manufacturing bill
- verify in-house released label
- notify the supervisor of deviations

P3. Monitor critical process parameters:
- document production equipment or product/finished readings, as required, e.g., temperature, humidity, speed of production, hold times, fill volumes, flow rate, pressure
- be vigilant wherever sterile products/materials are exposed, e.g. steps downstream of terminal filtration for products that are sterile-filtered
- watch/listen for system alerts or alarms that may indicate equipment or production issues
- notice unusual changes in odours
- notify the supervisor immediately of any unusual production processing changes

P4. Take in-process samples and conduct tests, as and when required, e.g., sterility, cell count, cell viability, purity, pH readings, osmolality readings

P5. Visually inspect the product for unusual characteristics that do not meet product specifications:

- notify the supervisor immediately of any unusual-looking product, e.g., incorrect size, colour, viscosity, foreign material
- isolate non-conforming products through proper labelling and physical segregation (quarantine)

P6. Take samples for finished/final product testing:

- ensure the correct number of samples are set aside
- ensure each sample is correctly labelled

P7. Clean and disinfect production equipment between product batches or at specified intervals e.g., line clearance or changeovers:

- do not mix batches
- remove all materials and supplies, including related documentation, forms, and labels
- remove equipment, as required

P8. Document testing and sampling:

- submit labelled samples to quality control personnel/testing laboratory

2.2.2.8.3 Knowledge

Competent technologists/technicians must know:

K1. Sampling as defined in Good Manufacturing Practices guide for drug products (GUI 0001), Quality control department C.02.015 - 5

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Specifications of materials and supplies

K5. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K6. Importance of personal conduct and hygiene to cleanroom work and consequences of non-compliance

K7. Parameters of production processes

K8. In-process and finished/final product specifications

K9. In-process testing and sampling procedures

K10. Documentation requirements for product testing and sampling

2.2.2.8.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Type of production, e.g., batch, continuous

V2. Types of products and bio-manufacturing processes

V3. Types of required tests and samples

V4. Sampling schedules

V5. Site-specific rules

2.2.2.9 Follow cleanroom waste management procedures

2.2.2.9.1 Purpose

Waste is a source of contamination in a clean environment and must be managed to minimize the risk of contamination to personnel and products. The mishandling of waste can contaminate the cleanroom, which can cause the loss of production time and product. It can also cause illness and injury to cleanroom production personnel.

2.2.2.9.2 Performance

Competent technologists/technicians must:

P1. Review the production workplan to determine types of waste

P2. Use required Personal Protective Equipment (PPE), e.g., gloves

P3. Ensure the correct type and number of waste containers are available in the cleanroom, e.g., sharps, biohazard, radioactive, paper/towelling, and liquids:
- ensure waste containers are properly prepared, e.g., lined with biohazard autoclave bag

P4. Ensure waste containers are separated and positioned away from products, work areas, production materials, supplies and equipment to prevent contamination

P5. Set up small waste containers for specific types of waste in the work area to minimize movement in the cleanroom:
- discard small work area waste bags in appropriate cleanroom waste containers, as required
- re-load small work area waste containers, as required

P6. Dispose of any waste with minimal movement to prevent generation of spray/aerosols and air turbulence

P7. Ensure waste containers are properly sealed and disinfected/decontaminated before removal from the cleanroom

P8. Do not pick up any item that is dropped on the floor during production:
- alert co-workers of the fallen item(s) as a potential workplace hazard and move out of the way with foot, if able

- place items on the floor into appropriate cleanroom waste containers or for follow-up cleaning and disinfection after production is completed, at break or end of shift as part of clean-up

P9. Use waste pass-throughs to remove cleanroom waste containers from cleanroom

P10. Document unexpected waste and waste-handling compliance, as required

2.2.2.9.3 Knowledge

Competent technologists/technicians must know:

K1. Cleanroom waste management procedures as defined in Canadian Biosafety Standard, i.e., '4.7 Decontamination and Waste management - 4.7.2-4, 4.7.8-11

K2. Standard Operating Procedures (SOPs)

K3. Occupational Health and Safety standard requirements

K4. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K5. Importance of following correct gowning procedures and consequences of non-compliance

K6. Workplace Hazardous Information System (WHMIS) and Safety Data Sheets (SDS)

K7. Different types of waste, associated risks, and management requirements

K8. Biohazard exposure control plan

K9. Levels of biohazard risk of materials and waste

K10. Waste container requirements for cleanroom

K11. Documentation requirements for waste management procedures

2.2.2.9.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Types of materials being used, e.g., biohazardous acids

V2. Types of processes and types of generated waste

V3. Work area requirements, e.g., biosafety cabinet (BSC)

V4. Site-specific rules

2.2.2.10 Follow cleanroom documentation procedures

2.2.2.10.1 Purpose

Cleanroom documentation is critical for traceability and as a record of compliance. Good documentation practices are required in both manual entries for controlled paper records and electronic records. It facilitates regulatory inspections and provides evidence for audits. It is critical for identifying the root cause of contamination. Cleanrooms must also be protected from potential contamination from documentation materials such as paper, printers, notepads, and pens. Failure to follow correct procedures may result in contamination and non-compliant products and can impact the organization's traceability practices/reputation.

2.2.2.10.2 Performance

Competent technologists/technicians must:

P1. Review production work plans before work

P2. Identify documents that will be in the cleanroom:
- ensure all documents and writing implements are cleanroom-approved

P3. Determine documentation (e.g., batch record) requirements, including:
- what needs to be documented, e.g., traceability and inventory control numbers, inventory release information, critical tasks, calculations
- what needs to be signed off, e.g., task completion, samples, testing
- who signs off

P4. Identify verification requirements, including:
- what needs to be verified, e.g., materials, supplies and equipment inventory numbers, calculations
- who can verify, e.g., assistant, coordinator, supervisor
- when work is verified

P5. Document incidents, i.e., deviations from the work plan including action taken

P6. Keep documentation close to the work area, e.g., attached to the exterior of the biosafety cabinet, next to the work area

P7. Complete documentation at specified intervals

P8. Review documentation, ensuring:

- completeness
- accuracy
- legibility
- completion within required timelines
- traceable to individual(s) who completed it

P9. Submit documentation to supervisor/quality control, as required

2.2.2.10.3 Knowledge

Competent technologists/technicians must know:

K1. Documentation as defined in the Good Manufacturing Practices guide for drug products (GUI 0001), Records C.02.024.1 – 5-7

K2. Standard Operating Procedures (SOPs)

K3. Attributable, Legible, Contemporaneous, Original, Accurate (ALCOA) and ALCOA + (Complete, Consistent, Enduring and Available) documentation practices

K4. Traceability and inventory control systems and numbers for materials, supplies and equipment

K5. A record-keeping system, e.g., submission of records, record completion requirements

K6. Production processes, including critical tasks

K7. Potential contaminants associated with documentation, e.g., cellulose particles from paper, polymers from binders

K8. Importance of using cleanroom documentation materials

2.2.2.10.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Size of organization

V2. Degree of digitization, i.e. hard copy or electronic record-keeping systems

V3. Types of products and bio-manufacturing processes

V4. Number of critical tasks/processes

V5. Site-specific rules

2.2.3 Follow Cleanroom Exit and De-Gowning Procedures

2.2.3.1 Follow cleanroom exit and de-gowning procedures

2.2.3.1.1 Purpose

As technologists/technicians often work in contact with dangerous or hazardous materials, correctly exiting and de-gowning protects the technologists/technicians, the product and the environment. Cross-contamination between products manufactured in the same area or between products in different areas may lead to batch rejection. Incorrect de-gowning can compromise the health and safety of personnel.

2.2.3.1.2 Performance

Competent technologists/technicians must:

P1. Place any materials being removed from the cleanroom in the designated container to avoid contamination:
- decontaminate materials, as required
- do not remove dedicated items without permission

P2. Clean and disinfect surfaces and tools, as required

P3. Put away all tools in designated locations

P4. Follow access control protocols, e.g., use key card

P5. Use exit doors and transfer areas correctly:
- ensure the area to be entered does not have too many people present already, i.e. has not exceeded maximum occupancy for the area
- verify correct reading of devices that indicate airflow immediately before entry, as required
- allow the entry door to close and a predetermined period to pass before moving to open next door in the transfer area
- do not leave doors open
- do not open and close doors quickly

P6. Enter the gown removal area

P7. Remove outer gloves

P8. Remove safety glasses, as required

P9. Remove the hood and facemask

P10. Remove booties:
- move from ‘clean’ to ‘dirty’ side, as required

P11. Remove coveralls (‘jumpsuit’/‘bunny suit’):
- start at the top, rolling the gown inside out
- place the body on the ‘dirty’ side, as required

P12. Remove inner gloves

P13. Remove bouffant/hair net

P14. Remove shoe covers using cross-over bench procedures, as required

P15. Place items in designated containers/locations following facility protocols

P16. Remove and discard other items, as required, after exiting the change area

P17. Wash and sanitize hands, as required

2.2.3.1.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs)

K2. Occupational Health and Safety standards requirements

K3. Grades of cleanrooms as defined in GUI-0119 Annex 1 to the Good Manufacturing Practices Guide – Manufacture of sterile drugs

K4. ISO Clean Room Classifications and how they compare to the Grades defined in GUI-0119

K5. Gowning and exit requirements as defined by the Canadian Biosafety Standard, i.e., '4.4 Entry and Exit'

K6. Gowning and exit requirements as defined in GUI-0119, i.e., 'Personnel', including gowning materials

K7. Importance of following correct gowning procedures and consequences of non-compliance

K8. Types of contamination and their impacts on manufacturing, including biological (e.g., bacteria, viruses, spores), particle (e.g., dust, skin, foot-borne dirt) and chemical (e.g., sodium from hands)

K9. Gowning materials provide protection for personnel, products and environment

K10. Aseptic gowning certification program in use at the facility

K11. Distinction between single-use and reusable gowning materials

K12. Distinction between sterile and non-sterile surfaces of gowning materials

K13. Differential pressure within cleanroom spaces, including how it is maintained and used to aid in contamination control

K14. Access control protocols

2.2.3.1.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Sizes and types of gowning materials

V3. Reusable and single-use items

V4. Types of products, equipment and bio-manufacturing processes

V5. Site-specific rules

V6. Approved religious attire and items

2.2.3.1.5 Glossary

- ***Bunny suit:*** *protective clothing worn by an individual in a cleanroom that keeps human bacteria from contaminating the bio-manufacturing*

2.2.4 Comply with Workplace Safety Procedures for Cleanrooms

2.2.4.1 Follow workplace safety procedures for cleanroom

2.2.4.1.1 Purpose

Technologists'/Technicians' safety can be compromised by unsafe behaviour, moving equipment components, pressurized equipment and pipelines, steam, hot liquids, and heated surfaces, among other factors. Workplace environmental conditions can vary, e.g., temperature, humidity, noise, etc. Workers may be exposed to confined places, microbes, radioactivity, and hazardous chemicals. Technologists/technicians must be aware of and take precautions against cleanroom safety concerns. Taking rapid corrective action prevents smaller problems from becoming serious risks.

2.2.4.1.2 Performance

Competent technologists/technicians must:

P1. Review the production work plan before entry into the cleanroom:
- assess the safety of assigned tasks before beginning

P2. Follow communication and safety precautions when working alone or during unusual hours, as required, e.g. complete periodic check-ins

P3. Wear correct PPE for tasks, e.g., insulating gloves, safety goggles, acid-proof apron, and face shield:
- ensure equipment fits correctly

P4. Identify locations of safety equipment, e.g., emergency phone, First Aid kit, fire extinguisher, fire blanket, chemical shower, eyewash station, spill kit

P5. Use safe lifting techniques to avoid injury, e.g., wide base of support, squat to reach load, and do not attempt to lift items that are too heavy or awkward:
- use assistive equipment for lifting heavy or awkward items when required

P6. Avoid repetitive stress injuries

P7. Handle non-hazardous biological and chemical spills, as required:
- contain spill
- re-sanitize work surfaces and materials as required

P8. Do not retrieve items that fall to the floor:
- use the foot to move fallen items out of traffic flow

P9. Avoid leaning or sitting on cleanroom surfaces

P10. Do not touch your skin and face

P11. Do not leave hazardous equipment or materials unattended when in use

P12. Use lock-out, and tag-out procedures, as required

P13. Contact emergency personnel as soon as possible when required

P14. Store equipment and materials according to SOPs

P15. Report your own and others' unsafe work practices as necessary

2.2.4.1.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs)

K2. Occupational Health and Safety standard requirements

K3. Safe workplace practices as defined by the Canadian Biosafety Standard, i.e., '4.5 Work practices' and '4.8 Emergency response'

K4. Importance of following safety procedures in cleanrooms and consequences of non-compliance Pathogen safety, including levels of biohazards

K5. Workplace Hazardous Materials Information Systems (WHMIS), and how to read Safety Data Sheets (SDS)

K6. Employee safety rights, i.e., Right of Refusal to undertake unsafe work

K7. Typical cleanroom hazards and their impacts on the human body, e.g., chemicals, sharps, steam, hot liquids, excessive noise, radioactivity

K8. Personal protective equipment used for specific tasks, including fit and use

K9. Safe lifting techniques

K10. Use and disposal of sharps and biohazardous waste in cleanroom

K11. Waste disposal procedures in the cleanroom

K12. How to use safety equipment and stations, e.g., eyewash station

K13. Fire and explosion hazards in cleanrooms

K14. Importance of reporting unsafe work practices

2.2.4.1.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Level of automation

V3. Types of products and bio-manufacturing processes

V4. Types of PPE

V5. Site-specific rules

2.2.4.2 Respond to emergencies in the cleanroom

2.2.4.2.1 Purpose

Cleanroom environments and the associated work pose specific risks to technologists/technicians. Responding to emergencies quickly and appropriately protects the safety of the production team and the facility. Production workers must be aware of situations that may indicate an emergency and take appropriate action. Taking rapid responsive and corrective action prevents small problems from becoming serious issues that may threaten technologists'/technicians' health and lives, as well as protecting the integrity of the facility.

2.2.4.2.2 Performance

Competent technologists/technicians must:

P1. Contact emergency personnel and management as necessary

P2. Assess the emergency to determine immediate corrective action(s):
- evacuate immediately, leaving product and equipment in place, as required

P3. Use the safety shower for chemical decontamination of impacted technologist/technician and their clothing:
- the impacted technologist/technician must remain in the shower for the required time, e.g., fifteen minutes

P4. Use an eye wash station to mitigate chemical splashes in eyes:
- the impacted worker must remain in the station for the required time, e.g., fifteen minutes

P5. Use a fire extinguisher to extinguish fires:
- use the PASS method, i.e., **P**ull the pin, **A**im at the base of flames, **S**queeze the trigger, **S**weep the nozzle to smother flames

P6. Assess chemical spills:
- analyze the reaction taking place
- identify the type of spill, e.g., acidic, basic:
    - use pH paper as required

P7. Use spill response kits for chemical spills:
- select the correct equipment for the type of spill, e.g., solvents, acids/bases
- place absorbent dam or absorbent pillows, as required
- address the spill, e.g., use an acid neutralizer, soak up the chemical
- dispose of items appropriately, e.g., place them in a double bag or bucket

P8. Respond to incidents involving sharps:
- identify if the puncture is caused by a sharp alone or a sharp with material
- contact supervisor for guidance, as required

P9. Respond to incidents involving burns:
- stop work immediately
- consult SDS, as required
- follow first aid protocols

P10. Follow post-exposure prophylaxis procedure, as required, e.g., for burn, needle-stick injury

P11. For incidents involving co-workers:
- identify any chemicals being used
- contact emergency personnel as required
- take necessary first aid action, e.g., move person to eye wash station

P12. When working in a BSC, an emergency occurs, and it is possible and safe to do so:
- close or bag biohazardous materials
- close or cover any open materials
- remove hands slowly from the cabinet
- place BSC into safe operating mode or power off, as required

P13. For alarms requiring evacuation from cleanroom, e.g., building fire alarm, exhaust failure, power failure, hazardous gas alert:
- set work in place
- secure the product if possible and safe to do so, e.g., close the valve on the batch tank
- exit quickly in an orderly fashion
- use designated exits as required
- proceed to muster point without de-gowning

P14. Participate in incident reporting, as required

2.2.4.2.3 Knowledge

Competent technologists/technicians must know:

K1. Standard Operating Procedures (SOPs)

K2. Occupational Health and Safety standard requirements

K3. Safe workplace practices as defined by the Canadian Biosafety Standard, i.e., '4.8 Emergency response'

K4. Workplace Hazardous Materials Information Systems (WHMIS) and how to read Safety Data Sheets (SDS)

K5. Employee safety rights, i.e., Right of Refusal to undertake unsafe work

K6. Importance of following safety procedures in cleanrooms and consequences of non-compliance

K7. Pathogen safety, including levels of biohazards and safe handling procedures

K8. Typical cleanroom hazards and their impacts on the human body, e.g., chemicals, sharps, steam, hot liquids, excessive noise, radioactivity

K9. Cleanroom environmental monitoring systems, including what is being monitored and the type(s) of alarm signals

K10. Personal protective equipment used for specific tasks, including fit and use

K11. How to use safety equipment and stations, e.g., eyewash station, spill kit

K12. Fire and explosion hazards in cleanrooms

K13. Locations of emergency shut-offs

K14. Locations of muster points

K15. Importance of incident reporting

2.2.4.2.4 Variables, range of context

Competent technologists/technicians may need to work with the following variables:

V1. Class or grade of cleanroom

V2. Level of automation

V3. Types of alarms, e.g., audible, visual

V4. Types of products and bio-manufacturing processes

V5. Types of chemicals/materials and associated hazards

2.2.4.2.5 Glossary

- ***Muster point:*** *designated location where individuals are expected to assemble after an emergency evacuation*
- ***Prophylaxis:*** *action taken to prevent disease, especially by specified means or against a specified disease*

3. Acknowledgements

We want to extend our sincere gratitude to all the participants of the focus group for their invaluable insights and contributions. Your input has been instrumental in shaping the findings of this report. The following individuals participated in the focus group:

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ShelleyPancham-Candler	Principal	SRPC Consulting Inc.
Allen Xu	Production Manager	Industry 4.0 Club
Sven Ansorge	Associate Director, Technical Training	Canadian Alliance for Skills and Training in Life Sciences (CASTL)

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A cleanroom and service provider
Link:
https://www.connect2cleanrooms.com/who-we-are
https://www.connect2cleanrooms.com/knowledge-base/cleanroom-gowning-and-entry-procedure
https://www.cleanroomshop.com/blog/iso-14644-equivalents-for-eu-gmp-grades
Brief description:
ISO 14644-1: 2015 Cleanroom classification table and comparison to EU GMP classifications
Review of Gowning Qualification and gowning and entry procedures
Discussion of equivalents between ISO and EU GMPs

2. Name of Source:
Mecart cleanrooms
Link:
https://www.mecart-cleanrooms.com/learning-center/cleanroom-classifications-iso-8-iso-7-iso-6-iso-5/#:~:text=This%20ISO%20standard%20includes%20these,cleaner%20than%20a%20regular%20room
https://www.mecart-cleanrooms.com/learning-center/what-is-a-cleanroom/
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Brief description:
Cleanroom classifications
Cleanroom definition, applications and descriptions in detail about cleanroom air flow
Overview of GMP graded cleanrooms and their requirements

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(ISO) International Organization for Standardization
Link:
https://www.iso.org/obp/ui/#iso:std:iso:14644:-1:ed-2:v1:en
Brief description:
A Table of contents to ISO 14644-1: 2015 Provides forward, Introduction and definitions used for the ISO Cleanroom standards

4. **Name of Source:**
Setra
Cleanroom software and hardware controls manufacturer
Link:
https://www.setra.com/critical-environments
https://www.setra.com/blog/what-is-iso-14644-1-cleanroom-classification
Brief description:
Blog site provides details about cleanroom requirements for IS0 8

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Providers of cleanrooms and supplies
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Brief description:
Provides an overview of cleanroom classification systems with comparative tables of ISO standards, the now defunct US Fed standards, the British system of standards and the EU GMP classifications. Blog site contains details on how to carry out particle assessment in a cleanroom, gowning requirements to enter cleanrooms and cleanroom gowning and other practices
Cleanroom maintenance of ISO standards from gowning procedures, cleaning and contamination control

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Cleanroom component and services provider
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Brief description:
Covers definition, cleanroom requirements and classifications. Provides details for ISO class 5-8 cleanrooms

8. **Name of Source:**
Safety Culture
Cleanroom systems provider
Link:
https://safetyculture.com/topics/gmp/
Brief description:
Good overview of GMP and cGMP for companies. Provides details on the 5 components of GMP and 10 principles, as well as regulations, compliance, quality management and training

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World Health Organization Good Manufacturing practices for Medicines
Link:
https://www.who.int/news-room/questions-and-answers/item/medicines-good-manufacturing-processes
Brief description:
Purpose of GMP, benefits, discusses business opportunities and affordability from a company perspective

10. **Name of Source:**
Canadian Government Good Manufacturing Practices guide for drug products (GUI-0001)
Link:
https://www.canada.ca/en/health-canada/services/drugs-health-products/compliance-enforcement/good-manufacturing-practices/guidance-documents/gmp-guidelines-0001/document.html#a2.1.3
Brief description:
Canadian guide for companies to ensure regulatory compliance. Covers range of requirements from quality management to GMPs

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Pharma Specialists
Industry information website
Link:
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https://www.pharmaspecialists.com/2021/10/difference-between-gmp-and-glp.html#gsc.tab=0
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Current article on good documentation practices in the pharmaceutical industry
Discussion on distinction between GMP and GLP
Makes distinctions between calibration, validation and verification

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Pharmaguideline
Industry information website
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https://www.pharmaguideline.com/2012/07/overview-of-iso-14644-clean-room.html
Brief description:
Very specific details on correct documentation practices, e.g. how to correct data, how to date, types of ink
Brief overview of cleanroom classifications

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Resource from FDA news
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https://www.fdanews.com/ext/resources/files/marketing_files/cGMP-Meeting-Series-021215.pdf
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FDA based information on good documentation practices

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US FDA
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https://www.fda.gov/drugs/pharmaceutical-quality-resources/facts-about-current-good-manufacturing-practices-cgmp#:~:text=The%20main%20regulatory%20standard%20for,will%20be%20safe%20and%20effective.
Brief description:
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BioProcess Internations
Link:
https://bioprocessintl.com/manufacturing/fill-finish/aseptic-processing-in-formulation-fill-and-finish-choosing-between-barrier-and-isolator-technologies/
Brief description:
Discussion about aseptic processing and the technologies with a focus on RABS and isolators

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Industry organization
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https://www.pda.org/global-event-calendar/courses/pda-aseptic-processing-training-courses
Brief description:
Wide range of courses on aseptic processing, in-person courses in many countries

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University of Tennessee
Link:
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Brief description:
Comprehensive course on pharmaceutical aseptic processing

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https://www.cleanroomtechnology.com/news/article_page/Cleanrooms_solving_the_mystery_of_recurring_low_level_contamination/210812
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Discussion of Sterilization processes and relationship to aseptic processing. Site contains a wide variety of different articles related to cleanroom technologies and events with a focus on cleaning. Second site provides an example of cleanroom issue. Third site is article discussing use of biosafety cabinets in aseptic processing.

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https://angstromtechnology.com/what-is-a-cleanroom/#:~:text=A%20cleanroom%20is%20a%20controlled,%2C%20pharmaceuticals%2C%20and%20medical%20equipment.
https://angstromtechnology.com/waste-management-in-medical-cleanrooms/
Brief description:
Definition of a cleanroom and a discussion of the mechanics as well as links to other areas in site regarding cleanroom classifications, types of cleanrooms, and a very good overview of applications
Description of disposal of medical waste in the cleanroom environment, and considerations when designing a protocol

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Brief description:
Good definition and descriptions of cleanrooms and their features

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Brief description:
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Brief description:
Description of standards and phases of implementing cleanrooms
Overview of safety protocols and safety considerations when working in cleanrooms

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Link:
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Brief description:
Discussion of different cleanroom specifications

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Bulk Inside, industry resource
Link:
https://bulkinside.com/pharmaceutical-processing/#:~:text=Pharmaceutical%20Processing%20is%20the%20process,and%20manufacturing%20guidelines%20for%20quality.
https://fluidhandlingpro.com/pharmaceutical-manufacturing/
Brief description:
Description of pharmaceutical processing, equipment, and processes, technology and manufacturing perspective
Details on different aspects of pharmaceutical manufacturing covering equipment and technology

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Link:
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Brief description:
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Brief description:
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Brief description:
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Link:
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Brief description:
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https://www.pharmtech.com/view/rabs-and-advanced-aseptic-processing
https://www.pharmtech.com/view/best-practices-using-isolator-technology
Brief description:
Definition of aseptic processing, difference to sterilization and manufacturers' responsibilities
Discussion of use of RABS and advanced aseptic processing
Discussion of how to choose isolators and best practices for their use

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Description of program in Pharmaceutical Manufacturing Technology

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Oxford College
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https://www.oxfordedu.ca/programs/pharmaceutical-manufacturing-technologist/
Brief description:
Description of Pharmaceutical Manufacturing Technologist Program

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Red River College Polytechnic
Link:
https://catalogue.rrc.ca/Programs/WPG/Fulltime/PHAFF-CT
Brief description:
Course description for Pharmaceutical and Food Manufacturing

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CASTL (Canadian Alliance for Skills and Training in Life Sciences)
Link:
https://castlcanada.ca/training-and-education/
Brief description:
Description of training programs offered by CASTL

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Blue Thunder Technologies, technology provider
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Brief description:
Article discussing the difference in using isolators versus RABS (Restricted Access Barrier Systems)

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Cleanroom World
Link:
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Brief description:
Available quick view of a wide range of training DVDs focused on cleanrooms, from GMP introduction to laboratory skills, Quality Auditing etc.

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John Hopkins University
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https://www.bme.jhu.edu/wp-content/uploads/2020/02/safety_manual.pdf
Brief description:
Safety manual for working in university cleanroom facilities at the university

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Ben Gurion University
Link:
https://in.bgu.ac.il/en/nano-fab/Site%20Assets/Pages/booking/Clean-Room-Work-Safety-Protocol.pdf
Brief description:
Safety protocol for working in university cleanrooms

40. **Name of Source:**
University of Nevada Las Vegas
Link:
https://www.unlv.edu/sites/default/files/24/SEB-Cleanroom-Manual.pdf
Brief description:
Safety protocol for working in university cleanrooms

41. **Name of Source:**
University of Texas Dallas
Link:
https://cores.research.utdallas.edu/cleanroom/
Brief description:
Safety protocol for working in university cleanrooms

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High-Tech Conversions
Link:
https://high-techconversions.com/product-category/cleanroom-documentation/
Brief description:
Documentation and other products available to work in cleanrooms

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Link:
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Brief description:
Comparison between isolators and RABS

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Pharmaceutical Inspection Convention
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Brief description:
Guidance for inspectors of isolators for training purposes to have inspectors trained for inspecting isolators used in aseptic processing using sporicidal

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Packaging Digest online resource
Link:
https://www.packagingdigest.com/pharmaceutical-packaging/restricted-access-barrier-systems-rabs-isolators-the-perfect-combination-of-robot-system-safety-and-aseptic-drug-manufacturing
Brief description:
Use of isolators, RABS and Robotics/automation in aseptic processing

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https://www.groninger-group.com/en/pharma/syringe-filling-machines/?utm_term=syringe%20filling&utm_campaign=Search+%7C+US+%7C+Pharma&utm_source=adwords&utm_medium=ppc&hsa_acc=6545606070&hsa_cam=11492171715&hsa_grp=109476627022&hsa_ad=624589359563&hsa_src=g&hsa_tgt=kwd-19675931&hsa_kw=syringe%20filling&hsa_mt=b&hsa_net=adwords&hsa_ver=3&gclid=CjwKCAjwu4WoBhBkEiwAojNdXnKn2xMeQ-JwIUOeFnxBOxEcmmZmNxLQ4FjkaD6K7GC3WyJpyBCCuBoCnxQQAvD_BwE
Brief description:
Discussion of groninger's automation for filling syringe cartridges and vials

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Use of isolator lines for filling

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Link:
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Brief description:
Video of completely automated sterile filling line

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Comecer
RABS manufacturer
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https://www.comecer.com/rabs-restricted-access-barrier-systems-for-aseptic-processing-pharmaceutical-products/
Brief description:
Descriptions of various forms of RABS and equipment for aseptic processing

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Millipore Sigma
Cleanroom supplier
Link:
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Brief description:
Discussion and links to closed processing, advantages
Video of isolator filling lines and how equipment maintains aseptic environment

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Piedmont National
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https://piedmontnational.com/semi-automatic-vs-fully-automatic-machines/#:~:text=Generally%2C%20semi%2Dautomatic%20equipment%20includes,it%20with%20minimal%20operator%20assistance.
Brief description:
Use of semi and fully automated machines especially for packaging and packing

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RNA
Automation manufacturer
Link:
https://www.rnaautomation.com/insight/semi-automated-vs-fully-automated-which-one-is-right-for-your-manufacturing-process/
Brief description:
Discussion on use of semi and fully automated systems for manufacturing processes

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Brief description:
Descriptions of various forms of equipment and manufacturing lines for aseptic pharmaceutical processing

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Descriptions and graphics of various forms of equipment for aseptic processing for pharmaceutical processing

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https://www.fda.gov/files/drugs/published/Production-and-Process-Controls--Overview-of-CGMP-Regulations-and-Regulatory-Expectations.pdf
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Training program for regulatory inspection of GMPs and FDA regulatory inspections

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Task Force on Sterile Pharmaceutical Products by Aseptic Processing prepared for the Ministry of Health, Labour and Welfare of Japan
Link:
https://www.pmda.go.jp/files/000153543.pdf
Brief description:
Descriptions of different processes and requirements used in pharmaceutical manufacture using aseptic processing

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University of Auckland
Link:
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Brief description:
Description of different types of waste and considerations for disposal in cleanrooms

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Cleaning protocols for cleaning in medical cleanrooms, BSCs, controls, etc.

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Clean Room Work Protocol
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chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://in.bgu.ac.il/en/nano-fab/Site%20Assets/Pages/booking/Clean-Room-Work- Safety-Protocol.pdf
Brief description:
Description of Clean Room Work Protocols, including attire and entering the cleanroom.

60. **Name of Source:**
ISO 14644-5 International Standard – Cleanrooms and associated controlled environments – Part 5. Operations
ISO 14644-5:2004(E)
Link:
ISO 14644-5:2004 - Cleanrooms and associated controlled environments — Part 5: Operations
Brief description:
ISO International Standard that addresses normative and informative operational requirements related to: providing a system that defines policies and operational procedures; clothing used to isolate human-generated contamination from the cleanroom environment; training of personnel inside the cleanroom and monitoring their compliance to specified procedures and disciplines; transfer, installation and maintenance of stationary equipment (selection criteria is not discussed); selection and use of materials and portable equipment in the cleanroom; maintaining the cleanliness of the cleanroom through systematic cleaning and monitoring procedures.

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Kimberly-Clark Professional. Proper Cleanroom Gowning Can Minimize Contamination Risk. May 2022
Link:
https://www.kcprofessional.com/en-us/workplace-insights/health-and-safety/proper-cleanroom-gowning
Brief description:
Discussion of gowning processes in the pharmaceutical industry.

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IEST. IEST-RP-CC027: Personnel Practices and Procedures in Cleanrooms and Controlled Environments
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Brief description:
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Production Automation Corporation. Cleanroom Cleaning, Gowning, and Maintenance – Procedure, Contamination and ISO Protocol
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Brief description:
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Link:
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Brief description:
Description of cleanroom gowning

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Link:
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Brief description:
Description of cleanroom gowning and de-gowning.

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Labconconco. Laminar flow in the laboratory
Link:
https://www.labconco.com/articles/laminar-flow-in-the-laboratory
Brief description:
Description of laminar flow

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Health Canada. GUI-0119 Annex 1 to the Good manufacturing practices guide – Manufacture of sterile drugs (GUI-0119)
Link:
https://www.canada.ca/en/health-canada/services/drugs-health-products/compliance-enforcement/good-manufacturing-practices/guidance-documents/gmp-guidelines-annex-1-manufacture-sterile-drugs-0119/document.html#pr
Brief description:
Health Canada regulations for GMPs

68. **Name of Source:**
Govt of Canada. Canadian BioSafety Standards, 3rd Edition.
Link:
https://www.canada.ca/en/public-health/services/canadian-biosafety-standards-guidelines/third-edition.html#a4.5
Brief description:
Canadian standards for biosafety and biosecurity

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Health Canada. Good manufacturing practices guide for drug products (GUI-0001)
Link:
https://www.canada.ca/en/health-canada/services/drugs-health-products/compliance-enforcement/good-manufacturing-practices/guidance-documents/gmp-guidelines-0001/document.html#a3.1.1
Brief description:
GMPs for drug products

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Parenteral Drug Association (PDA) SoCal Chapter. Aseptic Operations and Cleanroom Principals. Nov 2019
Link:
https://www.pda.org/docs/default-source/website-document-library/chapters/presentations/southern-california/2019-aseptic-day/paul-andrea---aseptic-operations-cleanroom-principals.pdf?sfvrsn=c5e96481_8
Brief description:
Presentation. Common issues and non-compliance issues in aseptic processing and their causes.

71. **Name of Source:**
ASQ CPGP Certified Pharmaceutical Good Manufacturing Practices Professional Body of Knowledge
Link:
https://p.widencdn.net/uu66jp/40179_CPGP_Cert_Insert
Brief description:
Description of Body of Knowledge tested in the certification process, including taxonomy levels assessed.

72. **Name of Source:**
Cleanroom Gowning Compliant with EU GMP Annex 1: An Overview
Link:
https://www.bioprocessonline.com/doc/cleanroom-gowning-compliant-with-eu-gmp-annex-an-overview-0001
Brief description:
Description of gowning process requirements for different classes of cleanrooms

73. **Name of Source:**
Dupont. Gowning Procedures
Link:
https://www.dupont.com/content/dam/dupont/amer/us/en/personal-protection/public/documents/en/Gowning_Procedure.pdf
Brief description:
Description of non-sterile and sterile gowning procedures

5. Gathering the data

5.1 Preliminary Primary and Secondary Research

Primary and secondary research was conducted to determine an appropriate title and scope for this skill cluster. This included an hour-long Zoom interview with a subject matter expert identified by BioTalent Canada. Extensive secondary research was conducted to access national and international sources of information. *See Appendix B for a full list of sources consulted*.

Based on the research, a draft scope definition for the skill cluster was developed, including embedded questions. A draft DACUM (Developing a Curriculum) chart and drafts of potential competencies for the skill cluster were developed.

5.2 One-day Industry Focus Group

The National Skill Cluster Development Industry Focus Group was held in Toronto, Ontario, on September 28th, 2023, at the Alt Toronto Airport Hotel

BioTalent Canada invited a representative group of subject matter experts (SMEs) who worked in various sizes and types of organizations and geographic regions of Canada to a focus group. Ten (10) SMEs participated. Two facilitators led the SMEs through various group activities to achieve the focus group objectives. *Details on the process followed can be found in the Focus Group Report in Appendix A*.

5.3 Site Visit

While not part of the initial scope of work, TL Davies decided to visit a bio-manufacturing facility to further refine the Skill Cluster documentation. This was completed at the expense of TL Davies Consulting, including travel costs, as TL Davies believed the benefit to the project would be very positive.

Following an invitation from focus group participant Gayle Piat, Director of Alberta Cell Therapy Manufacturing (ACTM), a TL Davies consultant, travelled and interviewed additional subject matter experts on site in Edmonton, Alberta, on October 11, 2023. The employees of ACTM spent several hours with the consultant, greatly contributing to the draft documentation, especially for competencies like ‘work in a biosafety cabinet (BSC)’. This was an extremely beneficial additional step in the Skill Cluster development process.

5.4 Ratification Process

Following the Industry Focus Group and the Site Visit, the subject matter experts' input, decisions and direction were incorporated into the draft scope, DACUM and competencies. TL Davies Consulting conducted an internal group edit. The draft DACUM and associated competencies were sent by email/BioTalent Canada's online platform to the focus group participants for further feedback and finalization. These drafts included many pointed questions to be answered by the subject matter experts, including questions related to titles, terminology, processes and accuracy.

The ratification period was extended two times to allow sufficient time for the industry's input to accommodate the subject matter experts' demanding work schedules. The response rate was extremely high: Eighty-nine percent (89%) of the subject matter experts responded during the ratification period. The responses were thoughtful and comprehensive. There was no conflicting feedback that required further discussion and decision-making.

All feedback was analyzed and collated, and the resulting Skill Cluster documentation was updated to reflect the input and decisions made during ratification. The result is a final, validated National Skill Cluster for Bio-Manufacturing Technologists/Technicians in Cleanrooms in Canada in 2023, which includes four new Major Skill Areas and 15 new competencies. This documentation will form the basis for training and assessments addressing the current industry skill gaps.

6. Partners

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BioAlberta
BIOQuébec
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Canadian Alliance for Skills and Training in Life Sciences (CASTL)
Gowling WLG
HealthPartners
Life Sciences British Columbia
Life Sciences Nova Scotia
Life Sciences Ontario
McGovern Management Group Inc. (MMGI)
PEI BioAlliance
Stem Cell Network

Bronze
Bioenterprise Corporation Canada
Bioindustrial Innovation Canada
Blue Branch
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Brock University
City of Mississauga
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Corporate Traveller Canada
EMILI (Enterprise Machine Intelligence and Learning Initiative)
Integrated Project Services (IPS)
Meeturtalent Inc.
Montréal Invivo
Notch Therapeutics
Research NB
Riipen – Advance Ontario
Science to Business Network
ZerotoOne Strategic
McMaster University – DeGroote School of Business
Northeastern University – Toronto Campus
Seneca College of Applied Arts and Technology
Toronto Metropolitan University
University of Alberta – Faculty of Engineering
University of British Columbia – Faculty of Science
University of Calgary- Schulich School of Engineering
University of Manitoba
University of Toronto
University of Toronto – Master of Management of Innovation program
University of Victoria – Biomedical Engineering
University of Waterloo
York University

Supporting
BioBenefits
BIOTECanada
Calgary Region Immigrant Employment Council (CRIEC)
Canurta
City of Toronto
Glyconet
Medtech Canada
Ontario Bioscience Innovation Organization

Showcase
BioConnect
Eurofins CDMO Alphora Inc
Global Institute for Food Security
Laboratories Charles River
Ottawa Hospital Research Institute
Providence Therapeutics Holdings Inc.
Resilience Biotechnologies
Sanofi Pasteur Limited
Xenon Pharmaceuticals Inc
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Academic
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