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DESIGN OF BSL3 LABORATORIES (CHAPTER 7)

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ABSTRACT

This chapter will provide design and layout information for Biosafety Level 3 (BSL3) laboratories showing how the guidelines translate into three dimensional architectural facilities. The basic models of the BLS3 laboratory will be presented with diagrams:

- BSL3 laboratory with anteroom or workroom as access zone
- BSL3 laboratory with restricted corridor as access zone
- BSL3 laboratory with BSL2 laboratory as access zone
- BSL3 laboratory suite

INTRODUCTION

The main issue regarding the layout of BSL3 laboratories in Biosafety in Microbiological and Biomedical Laboratories (BMBL) (DHHS, 1993) deals with access control by passage through two doors in series. This requirement has influence on how the BSL3 facility is designed and the laboratory workflow. As indicated in the Laboratory Safety Monograph, (DHHS, 1979) there have been a limited number of models utilized for laying out these facilities; however, there are many permutations of these models. The first three models are similar in nature. The difference between these models is the type of space one uses as the access zone to the BSL3 areas; an anteroom, a corridor or a laboratory. Each model should be used based on the program to be housed and it's specific requirements. Room size and equipment layout is also critical to BSL3 laboratory operation.

BASIC MODELS

BSL3 Laboratory with Anteroom or Workroom as an Access Zone

The simplest BSL3 facility is a two-space facility with an entry door from an access corridor into an anteroom or workroom that serves as an access zone for the BSL3 portions of the facility. This anteroom can serve for clothes changing, supply storage and other functions that support the work in the BSL3 module. Work with hazardous agents that require BSL3 containment must be handled in the BSL3 space accessed through a second door. With single room facilities the anteroom is generally small in size, as there are limited functions that can take place in this area. A variation on the anteroom is to enlarge it into workroom. This allows preparation activity to take place near but outside of the BSL3 labs. As shown in Figure 1 the anteroom can be used to serve single or multiple BSL3 spaces.

This model of a BSL3 facility generally does not have a dedicated autoclave within it, usually due to cost and space limitations. The use is limited because functions such as centrifugation of live agents must occur in the BSL3 room with other functions such as tissue culture. However; storage of frozen agents in the anteroom has been found to be acceptable by many organizations. Figure 2 illustrates a typical layout.

Although it has limited use, this model of a BSL3 facility is popular due to the low cost of construction and the ease of using it for a BSL2 tissue culture when not in use at BSL3. It is generally found where small-scale sporadic BSL3 work is anticipated.

BSL3 Laboratory with Restricted Corridor as Access Zone

A second model provides access to BSL3 spaces directly from a corridor that has been closed to

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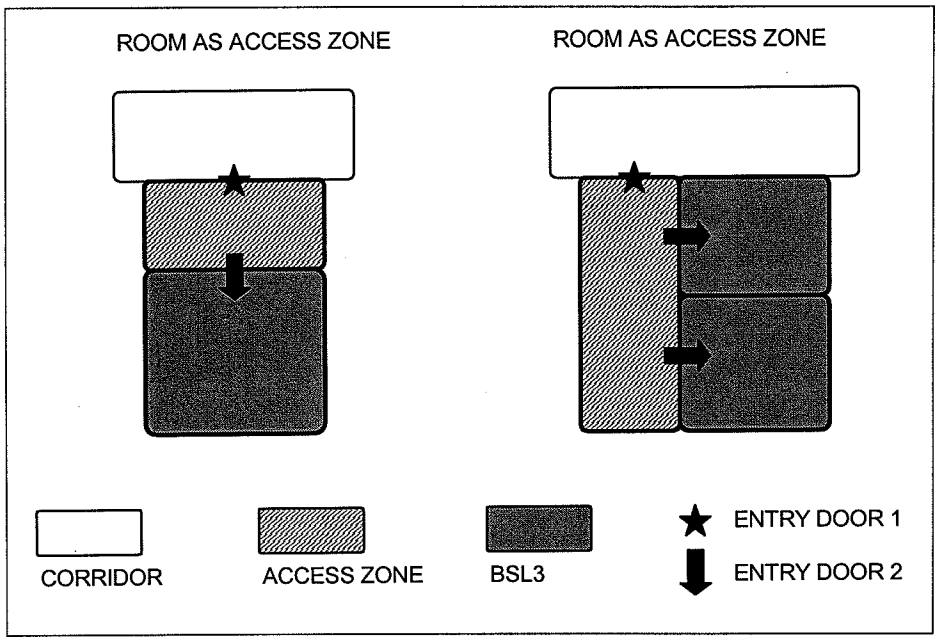
FIGURE 1
BSL3 with Anteroom as Access Zone.



through traffic. The first door is encountered when entering the corridor and the BSL3 space begins when entering the rooms off the corridor.

This model has the same disadvantages as the prior one. Depending on the size of the program, an autoclave may be provided within the facility to decontaminate waste. This model is often used when there are a large number of small separate BSL3 programs. This model should be considered when converting existing laboratory space to BSL3, as often this concept will reduce the amount of construction required.

BSL3 Laboratory with BSL2 Laboratory as Access Zone

A modification to the above models is to enlarge the anteroom into a working BSL2 laboratory and provide small BSL3 modules off of the lab.

This model works well for isolation rooms and small functional laboratories in clinical laboratory

FIGURE 2
Example of Typical Layout.

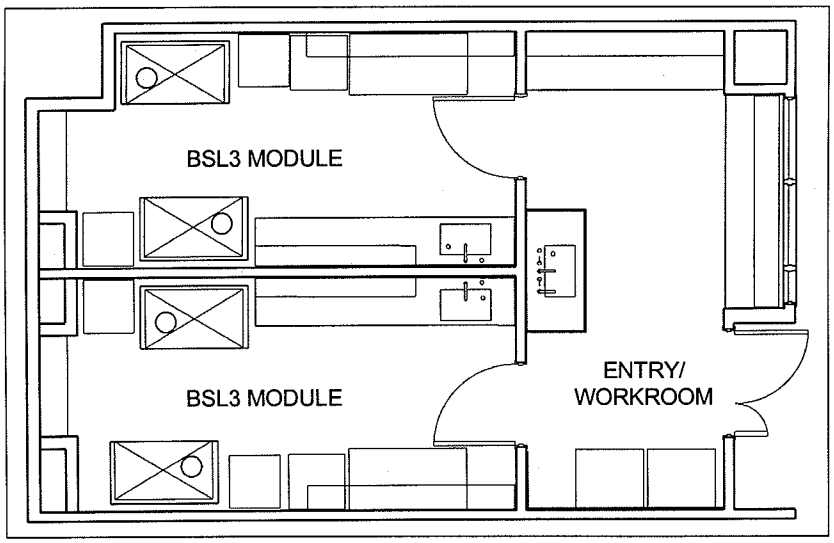
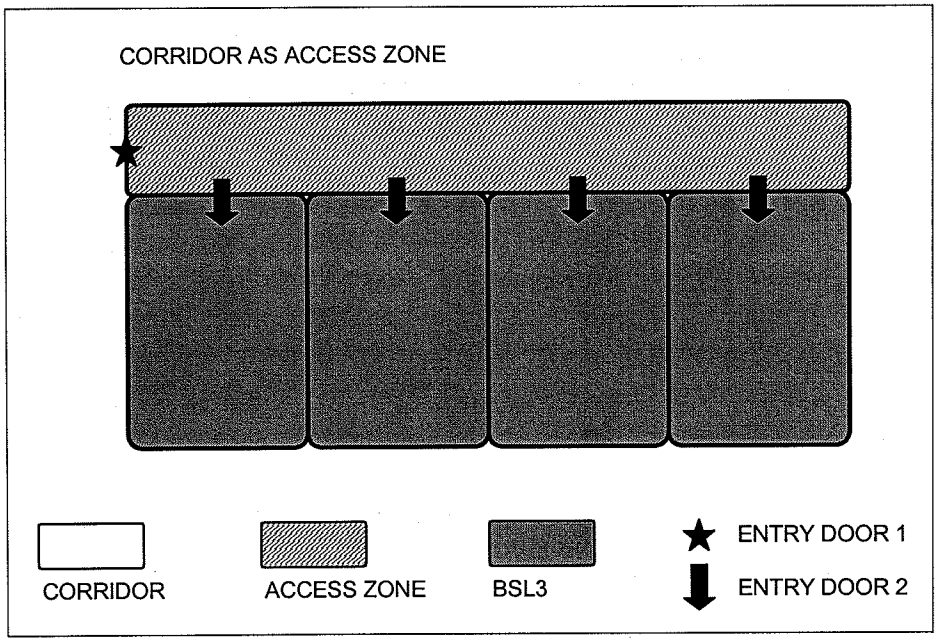


FIGURE 3
BSL3 with Corridor as Access Zone.



settings. Again, as in the initial model, due to the requirement that all BSL3 functions occur in the BSL3 space, this concept is limited to smaller scale BSL3 operations.

The BSL3 Laboratory Suite

More complex BSL3 laboratories work better in a suite concept that creates larger and more diverse spaces at BSL3. An anteroom leads into the suite with a BSL3 workroom. This workroom function as a preparation area that allows the modules to function effectively for dedicated purposes such as tissue culture. Additional rooms can be dedicated for equipment use, for centrifuges freeze dryers and other common equipment allowing shared use of this equipment.

FIGURE 4
BSL3 with BSL2 as Access Zone.

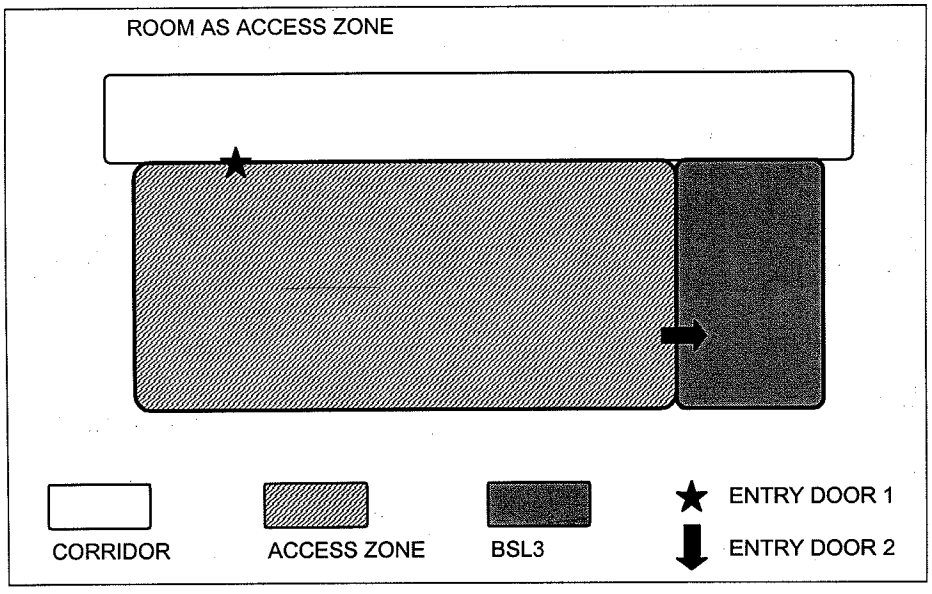
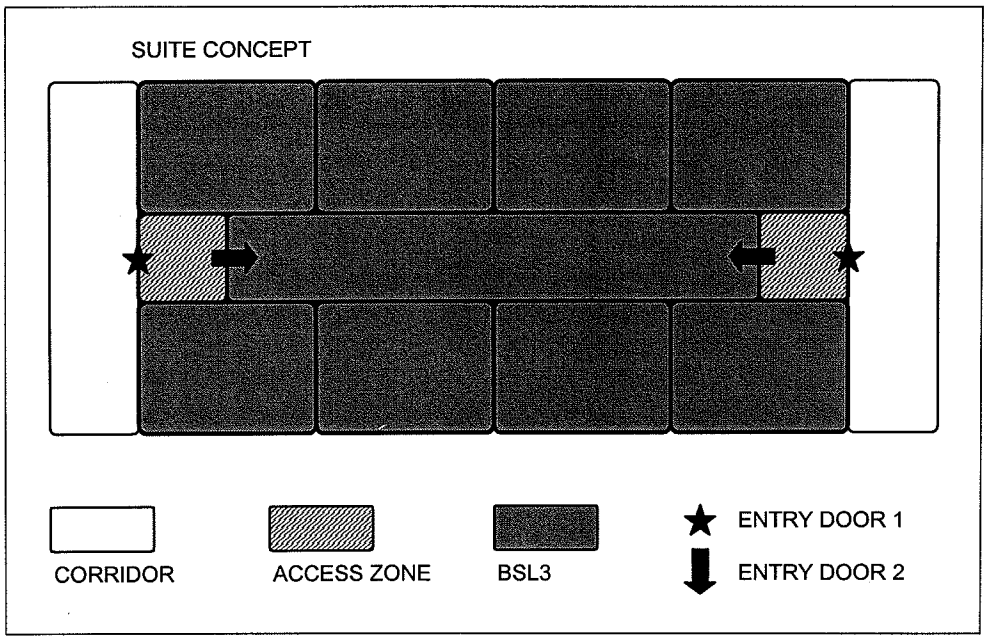


FIGURE 5
BSL3 Suite.



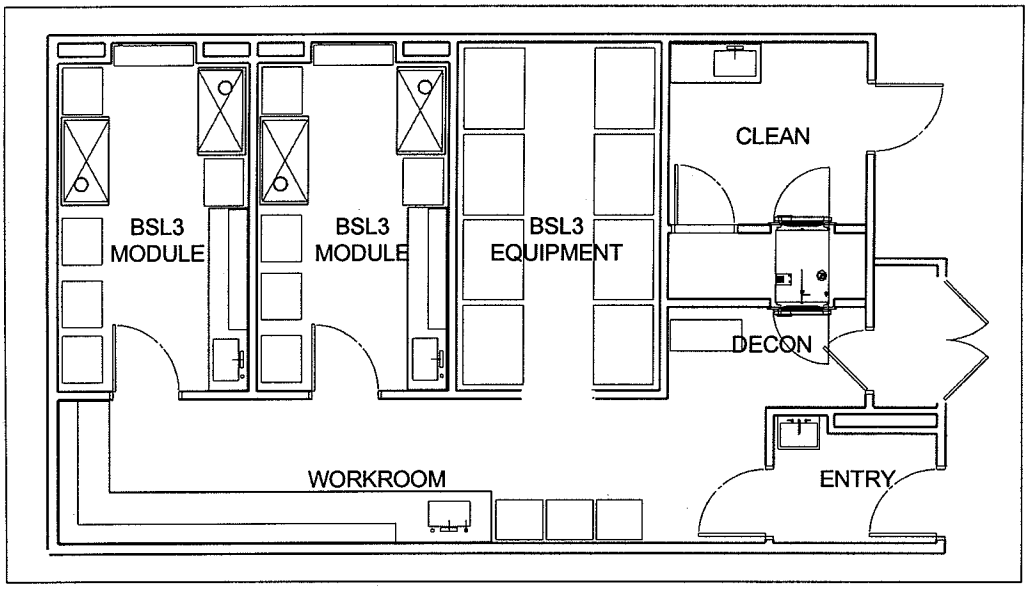
This segregation can increase safety and effectiveness by creating good workflow in the BSL3 laboratory. This size facility often includes pass through autoclaves to allow decontamination to take place prior to hazards leaving the BSL3 facility.

This larger suite concept works well for more complex multi-functional BSL3 areas such as those used for large volume TB testing and identification, and large research programs dedicated to studying BSL3 agents.

Design Issues for BSL3 Modules

The basic space in a BSL3 facility is the module where the infectious agents are cultured and manipulated. These modules are usually sized to accommodate comfortable work in one or two biosafety

FIGURE 6
Typical layout for BSL3 Suite.

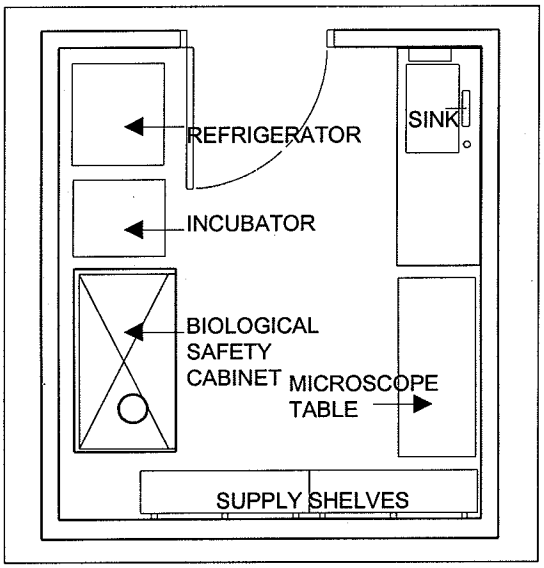


cabinets in the same room. Sizes of the modules generally range from 8 x 10 feet for a single biosafety cabinet to 11 x 20 feet for two biosafety cabinets. The layout of the module should facilitate working in a biological safety cabinet by placing storage shelving, incubators and other relate equipment as close to the cabinets as possible. BSL3 modules usually have less casework than other laboratories with plenty of floor space for large equipment. Doors into the BSL3 facility should be sized to allow easy access for moving equipment such as biosafety cabinet and freezers.

The layout of the modules should place the biological safety cabinets away from the doors and walking paths to keep the cabinets operating properly. Figure 7 shows the layout of a small BSL3 module with the biological safety cabinet placed to minimized performance disruptions (Crane, 1994). The biosafety cabinet and the room size must be closely coordinated to ensure that the door swing does not suck or push air into the cabinet causing loss of containment. In a small room the preferred location is on a side wall.

If two cabinets are place in a single room the preferable location is face to face (possibly with a 24 to 36 inch offset) at the rear of the room as this location is the least disruptive to cabinet performance. If the cabinets are side by side, a person

FIGURE 7
Typical Small Module with Single Biological Safety Cabinet.



walking to the second cabinet will affect the containment capability of the cabinet closest to the door.

BSL3 modules usually have partial walls of benches with a sink for handwashing. For tissue culture rooms microscopy tables are often provided for checking specimens. Space for incubators, refrigerators and freezers should also be provided.

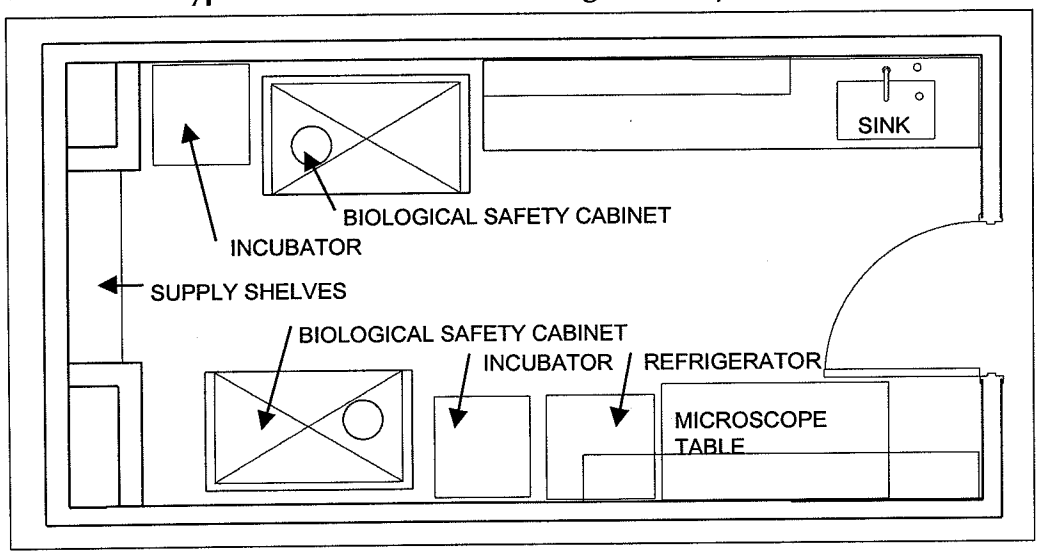
Design Issues for Associated BSL3 Spaces

Entry and gowning areas, if provided, should be developed to allow for easily following the entry and exit protocols for the laboratory. Considerations should include lockers for personnel effects, shelving for gloves, gowns, masks and booties or jump suits if these items are required. Waste receptacles for removed protective clothing should be provided. A sink should be considered in this area. The entry gowning area is also a good space to store spill control and decontamination equipment and supplies.

BSL3 modules are often used for tissue culture functions. As there are numerous preparatory and related uses in a biomedical laboratory, common work areas outside of the BSL3 modules should be considered to house these functions.

Separate rooms for equipment support and storage should be considered. Centrifuges and other

FIGURE 8
Typical Module with Two Biological Safety Cabinets.



large equipment can be easily shared if placed in an equipment room rather than a BSL3 module. The separation of this equipment can reduce hazard by isolation in the event of an accident such as a centrifuge rotor failure. The heat load from equipment such as low temperature freezers is more easily handled if grouped together where additional focused cooling such as fan coil units can be applied.

Although decontamination autoclaves are not required to be located within BSL3 laboratories, laboratories with significant amounts of hazardous waste should consider providing pass through autoclaves to decontaminate materials leaving the facility. The intent of this is to reduce the volume of infectious waste passing through corridors. Adequate holding space for the waste prior to decontamination is necessary to reduce potential for exposure to infectious agents. Consideration should be given to providing a service closet for the autoclave, as shown in Figure 6, to minimize the heat from the outside of the chamber from entering the work area. Access to this service area should be from outside the BSL3 facility to allow service to take place without exposing the service personnel to the BSL3 environment. Exhaust ventilation should be provided above the exterior door of the autoclave to remove heat and steam when the door is opened. The area outside the BSL3 suite where the autoclave discharges can also be used for gas cylinder storage to keep delivery personnel from having to enter the BSL3 area.

Animal holding space may be incorporated in BSL3 facilities. Care should be taken to provide appropriate containment equipment to keep aerosols generated by animal care from entering the general room environment. BSL3 animal facilities often contain personnel showers and change rooms to increase environmental protection. Figure 9 shows an example of a BSL3 animal suite with decontamination facilities.

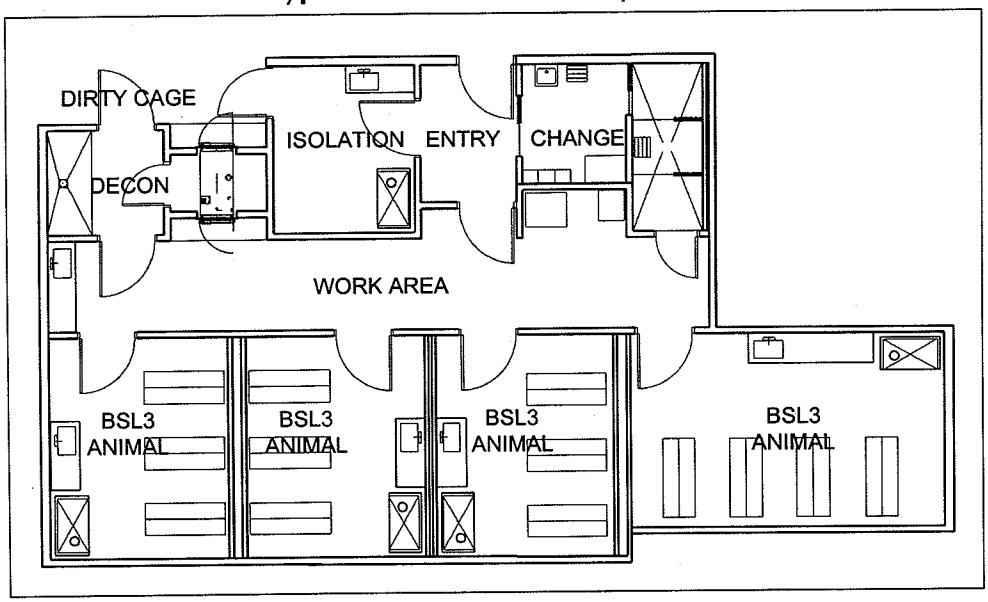
Enhanced BSL3 Laboratories

In some instances, it may be necessary to add facility features not required by the BMBL guidelines. Generally, this is increased environmental protection in the form of HEPA filtration of the exhaust air, effluent decontamination, or the addition of a personnel shower in the changing area.

CONCLUSION

Programmatic issues drive the layout of BSL3 facilities. The current BMBL facility guidelines have minimal impact on the layout. The model chosen for a specific facility must be based on the intended scope of operations for the facility to be successful.

FIGURE 9
Typical BSL3 Animal Facility Suite.



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