The amount of ash collected in the ESP:

$$(11.5\ \text{kg/d})/(1 - 0.998) = 5770\ \text{kg/day}$$

2. Hg exiting the stack with the fly ash:

$$(11.5\ \text{kg ash/day})(2.42 \times 10^{-6}\ \text{g Hg/.001 kg ash}) = 0.03\ \text{g Hg/day}$$

Hg leaving the stack as vapor:

$$0.2 \times 10^{-3}\ \text{g Hg/dscm} \times 675\ \text{dscm/min} \times 60\ \text{min/h} \times 24\ \text{h/day} = 194.40\ \text{g/day}$$

The total mercury exiting the stack = 194.40 + 0.03

= 194.43 g/day

(Adapted from Reynolds, J.P., et al., *Handbook of Chemical and Environmental Engineering Calculations*, Wiley-Interscience, New York, 2002.)

20.8 ADVANTAGES AND DISADVANTAGES OF INCINERATION

The greatest advantage to using incineration for the disposal of medical and infectious waste is th the organic component of the waste can be reduced by up to 95% of its original volume. Therefo significantly less waste must be handled, stored, or transferred to the disposal site (Hoeltge 199 Incineration will also detoxify the biological component of the waste. These factors are importa for both keeping operational costs down and reducing future liability.

Medical waste incineration has its own unique problems, however. First, following *The Law the Conservation of Mass*, waste is physically transformed into a variety of solid residues, gaseo compounds, and particulate matter. As indicated in Chapter 9, there is the potential for adve impacts to public health from these residues. A pressing concern involves the release of metals su as mercury. In decades past, hospitals had contributed almost 10% of all mercury from incinerati in the United States (U.S. EPA 1997). However, advances in Hg scrubbing technology, combin with effective waste segregation prior to incineration, have contributed to significant reducti in Hg emissions to the atmosphere. Another harmful result of incineration involves generation polychlorinated dibenzodioxins (PCDDs). PCDDs such as tetrachlorodibenzodioxin (TCDD) ha been linked to cancer, birth defects, and a host of other health problems (ATSDR 2011). PCDDs c additionally enter the food chain and bioaccumulate.

All types of wastes may be treated by incineration; however, a special permit is required incinerate low-level radioactive medical wastes. Ash from incineration of radioactive medi waste will remain radioactive. No other treatment technology may be used for radioactive or cy toxic wastes.

20.9 MICROBIAL INACTIVATION

Microbial inactivation refers to those physical or chemical processes that render microorganis incapable of multiplication. Such processes may either kill the organisms or injure them to t extent that repair and subsequent growth of cells is not possible. The effectiveness of medical wa treatment technologies tested during an EPA investigation is presented in Table 20.5.

Level I microbial inactivation destroys most disease-causing microorganisms. There is a kill of at least 10^5 vegetative bacteria and fungi, fungal spores, and viruses (in other words, an inactivation of at least 5 Log_{10} or greater); however, Level I may be unable to inactivate

TABLE 20.5
Evaluation of Level of Microbial Inactivation achieved by Medical Waste Treatment Technologies

Waste Treatment Technology	Microbial Inactivation: Level I	Level II	Level III	Level IV
Steam autoclave				
Lab test results[a]	Yes	Yes	Yes	No
Field test results[b]	Yes	Yes	Yes	Yes
Microwave				
Field test results[c]	NT	NT	Yes	No
Radio frequency				
Field test results[d]	NT	NT	Yes	No
Chemical				
Lab test results[e]	Yes	Yes	Yes[g]	Yes[g]
Field test results[f]	Yes	Yes	No[h]	No[h]

Source: Reproduced with kind permission from RTI, *Guidance for Evaluating Medical Waste Treatment Technologies*, Final Report, 94U-5400-005/01-F, Research Triangle Park, NC, 1993.

Note: NT = not tested.

[a] Benchtop and gravity displacement autoclaves, 121°C, 15 psi.
[b] Prevacuum system, 138°C, 30 psi; double-door gravity system, 163°C, 80 psi.
[c] Microwave treatment system (6 units at 2450 MHz each).
[d] Short wave RF system, 11–13 MHz.
[e] Chemical only, sodium hypochlorite 1000 ppm and 3000 ppm FAC prolonged exposure (≥3 h).
[f] Chemical/mechanical systems, sodium hypochlorite 1000, 2000, 3000 ppm FAC.
[g] Dependent on prolonged exposure (>3 h).
[h] Not achieved under normal operating conditions (<3 h exposure).

mycobacteria and bacterial spores. Level I inactivation may be accomplished by several physical or chemical processes.

Level II microbial inactivation is defined as significant inactivation of all microorganisms, with the exception of bacterial spores. Inhibition of at least 10^5 mycobacteria must occur in addition to Level I inactivation. Level II treatment implies some measure of tuberculocidal activity on the wastes (RTI 1993).

Level III inactivation indicates the kill of microbial life forms, as evidenced by inactivation of at least 10^4 of selected indicator spores that possess death curves similar to human pathogenic spores. Thus, *Bacillus subtilis* spores may be used to indicate Level III inactivation for moist heat treatment since they exhibit thermal death data similar to species of the pathogenic spore-forming *Clostridium*.

Level IV indicates the kill of microbial life forms, as evidenced by inactivation of 10^6 bacterial indicator spores recognized as most resistant to treatment. For example, the inactivation of at least 10^6 spores of *Bacillus stearothermophilus*, recognized as most resistant to moist heat, is an indication of Level IV inactivation by steam autoclaving (RTI 1993).

Nonincineration alternative treatment technologies are being increasingly relied upon, as public and regulatory pressures direct the medical industry away from incineration for treating medical and infectious waste.