BIOSECURITY AND BEST MANAGEMENT PRACTICES IN THE UNITED STATES AND WESTERN EUROPE FOR THE PREVENTION AND CONTROL OF INFECTIOUS DISEASES IN BREEDER FLOCKS AND HATCHERIES

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This paper will review biosecurity programs and other best management practices that can be used to either prevent or control specific infectious diseases in breeder flocks and their dissemination through hatcheries. It will also deal with historical perspectives, economic, political and practical considerations necessary to develop an effective program that will work.

A biosecurity program is designed to reduce the risks and consequences associated with the introduction of specific transmissible agents. Best management practices to achieve these goals are well known. These procedures will be reviewed but numerous references with more details are available (1,2,3.). The most effective biosecurity programs are also the most expensive to implement and require significant capital investment and motivation of management to be maintained. Therefore in reality, the most complete programs are most often used only for Primary Breeders and sometimes Multiplier Breeder Flocks but often are minimal or absent in broiler production flocks.

The cost of the biosecurity program must be consistent with the risk of infection, the impact of the disease on cost of production and the credibility achieved of the end product for either local or international markets. There must also be a return on this investment.

While biosecurity programs are usually designed to deal with specific disease agents such as *S. pullorum* or *Mycoplasma gallisepticum (MG),* many infectious agents, including catastrophic disease agents like Velogenic Viscerotropic Newcastle Disease and Highly Pathogenic Avian Influenza are also excluded for little or no additional cost.

Today in a modern poultry operation one can start with chicks known to be free of specific disease agents. We simply have to place them in an environment also free of these diseases and prevent the introduction of these agents. No small task, but possible.

Historically, the poultry industry had to use extraordinary measures to eradicate and control diseases such as pullorum, typhoid, MG and Avian Leucosis. In those days, pullorum was widespread and early testing procedures inadequate. When MG was recognized to be a major cause of respiratory disease and decreased egg production,

breeder flocks free of MG were not available to provide MG free chicks. So massive treatment programs using antibiotics, egg dipping and testing of every bird in the breeder flock was required to obtain MG free stock. It took years of effort and substantial investment by primary breeder companies to become MG free.

My point is, that today when there is a break of MG in a breeder flock, it is possible to start the next flock from MG free chicks and to place them in poultry houses that have been cleaned and disinfected be back in business. Also, hopefully, by this time you have some idea of how the MG was introduced into your flock. Your biosecurity program failed and may fail again.

A good biosecurity program also provides for control of some diseases by vaccination while requiring zero tolerance for others. For instance, most poultry industries would permit control of Mareks, Avian Encephalomyelitis and Infectious Bronchitis by vaccination. Some countries even permit vaccination for typhoid in meat birds, *Salmonella enteritidis* (SE*)* in commercial egg type birds, and one country even requires that all egg-type breeders be vaccinated for SE. Most developed countries however, do not permit the vaccination of primary breeder or grandparent flocks for MG.

Each country and its poultry industry must sit down together and develop a program that is best for them.

BEST MANAGEMENT PRACTICES TO PERMIT GOOD BIOSECURITY

For the purpose of this discussion lets divide the topics to cover breeder flocks, the hatchery, the feed mill and people control. Each of these topics is complex and could be the subject of a separate seminar. As has been stated earlier the most stringent efforts are reasonable for grandparent flocks with reduced requirements for multiplier flocks and broilers.

The location of the grandparent and multiplier breeder flocks is very important. Physical isolation of grandparent flocks should be thirty miles or more from concentrated areas of broiler, commercial-egg, turkey and back yard flocks. These locations also attract other poultry producers and may in the long term become another “concentrated poultry area”. The close proximity of these “other” poultry flocks greatly increases the risk to even the best biosecurity program. It may be necessary for the breeder company to purchase large tracts of land, or for the government to pass zoning laws which exclude poultry farming. This land could be zoned for crops or grazing. Pullet rearing farms should be at least two miles from breeder farms and single age units on the breeder farm should be one mile apart.

The Breeder Farm should be fenced and located away from public roads. Poultry company feed and service trucks should enter through a guarded gate and pass through a

drive through disinfectant vat. The upper part of the vehicle should be sprayed with a disinfectant. All other vehicles should not be allowed to enter the farm. The guard station and truck wash-disinfectant area should be located some distance from the poultry house. A record should be kept of all visitors entering the farm. Entry to the poultry house area should require all people to pass through a shower. This consists of a change room, walk through shower and a clean room with lockers for changing into clean clothes provided for all workers and visitors.

The construction of the poultry house should include concrete floors, rodent proof, cleanable walls and doors, and should be screened to exclude wild birds. Bulk feed tanks should be located adjacent to the fence line so that feed trucks do not have to enter the farm. Other needs for the breeder farm include a pass through room for egg decontamination and storage facilities and dead bird disposal facilities.

Requirements are somewhat reduced for pullet rearing and multiplier breeder flocks. The idea of these efforts is to create a physical barrier to keep people, vehicles, wild birds and animals out of the farm.

After the flock has been removed the house and grounds should be cleaned and disinfected. Listed below is the step by step cleaning, decontamination and vector control program published in the Proceedings of the United States Animal Health Association 1993. The article was written by Dr. Tom Holder and his committee which includes Dr. Robert J. Eckroade and others. Similar reviews are also available for use in commercial-egg and turkey flocks.

DECONTAMINATION OF THE POULTRY HOUSE

I. **Bird Removal**

A. Remove all dead and live birds from the building; including all escaped birds.

B. Immediately begin vector control procedures during bird removal. Refer to guidelines section on Vector control

II. **Dry Cleaning**

A. Turn off power to electrical equipment prior to dry or wet cleaning. Non-removable motors, switches, etc. should be dry cleaned with compressed air or brushing. Extreme care should be taken about not getting any sprays inside electric motors. Duct tape can be used to cover the slots in motor housing prior to wet cleaning and disinfection. The tape must be removed after wet cleaning and disinfection is completed.

B. Clean fans and other air inlets from the outside.

C. On the inside, brush, sweep, vacuum and wipe dust and other dirt from ceilings, light fixtures, beams, ledges, walls, fans, air inlets and walkways. Move from top to bottom.

D. Promptly open feeder lines and remove feed from trough, all line corners and all other points of feed accumulation.

E. Hard surface (concrete) floors can be cleaned faster and more easily than clay or earthen floors. Completely remove all litter. Hand sweeping and shoveling will be necessary around the perimeter, doorways, walkways, support poles, and corner, of most houses to do a satisfactory job. If possible, fill trailers with manure inside the house and cover before moving it to a disposal or composting site. Manure should not be spread near poultry facilities.

III. **Wet Cleaning**

Wet cleaning includes soaking, washing and rinsing steps. Use of hot water is preferred. Detergents and other surfactants are often added to washing solution to loosen debris and films and allow better penetration of cleaning agents. Salmonella can multiply to high numbers in the presence of debris and moisture. Therefore, the following steps should be executed without interim waiting periods.

A. Soften dirt in heavily soiled areas. A low pressure (200 to 300 psi) sprayer, delivering 10-30 gallons/minute has been considered adequate.

B. Washing. Professional contractors use a systematic spray technique. They start at the back and work toward the front of the building, spraying the ceiling first, then the walls, and finally the floor. Use sprayer attachments and nozzles that permit washing of hard to reach areas.

1. Wash ceilings and walls. Clean everything completely.
Although use of pressure sprays ranging from 200-2000 psi have been reported, washing pressures of 750-2000 psi appear to be preferred. At high pressure, however, special care and safety garments are needed. Pressure sprayers can cut human skin like a knife. Care must be exercised to follow the manufacturer's instructions for the use of this equipment.
2. Pay special attention not only to the top, but also to the underneath sides of troughs and obvious and hidden surfaces of all chains and augers.
3. Wash storage rooms, hallways, break, wash and restrooms.
4. Manually clean any areas that have resisted prior cleaning.

C. Rinsing

1. A final rinse is suggested to obtain a truly clean building and to reduce residues of cleaning chemicals.
2. Immediately remove all puddles. They are bacterial breeding grounds.

C. Danger of Carbon Monoxide Poisoning from Gasoline Engines.
The National Institute for Occupational Safety and Health (NIOSH) recently issued the following warning because of recent farm accidents:

1. Do not operate gasoline powered pressure washers or other machinery indoors to clean buildings because of the emission of carbon monoxide, a deadly gas.

IV. **Repairs**

All repairs to the house should be made at this point.

V. **Inspection**

Third party visual inspection for completeness of the wet cleaning and repair operations is recommended. This may be done by an outside authority or by an in-house unbiased employee responsible for quality control.

VI. **Disinfection**

Disinfection should be started within 24 hours of rinsing. Because disinfectants are effective only on clean surfaces, do not begin disinfection until the house has passed its inspection for proper cleaning.

A. Only clean potable water should be used for disinfection. Water from streams and ponds may reduce the effectiveness of disinfectants.

B. Heat Enhancement. All disinfectants, whether sprays, foams, aerosols, or fumigants, work best at temperatures above 65°F. Temperatures for chlorine-and iodine-based disinfectants should not exceed 110°F.

C. Dangerous Mixtures. Each disinfectant is the result of careful formulation, and any addition of detergents, surfactants or insecticides to a disinfectant without the approval of its manufacturer could dangerously reduce the efficacy of one or more of the products in the mixture. For economy, efficacy and human and flock safety, manufacturer's label instructions must be followed carefully.

D. Evaluation of Products. There has been an influx of claims for new salmonella disinfectants and control systems. Table 2 provides guidance on evaluation efficacy of various products.

E. One gallon of diluted disinfectant is ordinarily applied to approximately 100-150 square feet of surface area. The total amount of disinfectant solution needed is determined by the total surface area of the floor, ceiling and walls.

F. Follow application instructions of the manufacturer. Use of pressure sprays or thermal devices is advisable to help force disinfectants into wood pores, cracks and crevices that protect salmonellas. Spray pressures of 500-1000 psi have been suggested. Move from back to front and from top to bottom.

G. Dirt floors are virtually impossible to fully disinfect. Disinfectant has been applied to the floor at 1 gallon diluted disinfectant per 10 square feet. Investigators reported favorable results with chlorine and formaldehyde. Note formaldehyde warning below.

H. Decontaminate feed bins, boots, augers, hoppers and carts. Sanitize waterlines. Waterline and feed system directions have been published in *Biosecurity for Poultry*. Refer to Appendix for source. Be careful – metal and non-metallic components of watering systems can be damaged and lines plugged from improper use of sanitizing agents. Check with the manufacturer of farm water handling equipment before implementing any specific chlorine or other sanitation treatments of your wells and water lines. Water lines should be disinfected between flocks. Routine chlorination of poultry drinking water to a minimum 1 to 1.5 ppm free chlorine level has been reported to reduce the spread of salmonellas. A level of 1.5 to 2.5 ppm free chlorine is recommended in the last water trough.

I. In the past, direct application of formaldehyde solutions (formalin) has been used as a surface disinfectant for salmonella. Formaldehyde fumigation also has been used as a final crack and pore penetration step in salmonella disinfection, provided proper levels of relative humidity (at least 70%) and temperature (at least 70°F) were maintained. Such applications may soon be unlawful. **WARNING**: Formaldehyde and formalin are dangerous chemicals. Consequently, contact state/federal (EPA, OSHA, FDA) authorities and licensed

professionals before considering use! Gas masks, protective clothing and rescue plans are essential.

J. Promptly dry the building. Bullet space heaters have been used to speed drying in cold and damp climates.

K. Salmonella are invisible. Verify decontamination success by laboratory procedures.

Table 2. Properties and Examples of Common Disinfectants [ab]

Special Properties	Hypochlorites Chloramines	Iodophors	Cresols Phenols	Glutaraldehyde
Active against Gram negative Bacteria (Salmonella, E. coli, etc.)	Yes	Yes	Yes	Yes
Resistance to organic debris	Poor	Poor to fair	Good	Poor
Effect of hard water	None	None	None	Yes
Detrimental effect Of heat	d	d	No	No
Residual activity	e	Yes	Yes	Yes
Most effective pH Range	Acid	Acid	Acid	pH5-8.5
Compatibility with Anionic surfactants (soaps)	Yes	Yes	Yes	Yes
Compatibility with Non-ionic surfactants	Yes	Yes	No	Yes
Common Brands and Names				
	Chloramine –T	Betadine	Cresl-400	Ucarsan
	Clorox	Bio-Dyne	Environ-D	
	Halazone	Iofec	LpH-A G	
		Isodyne	Lysol	
		Losan	Orthophenylphenol	
		R.I.D.	PD256	
		Tamed Iodine	Tek-Trol	

[a] Modified from *Biosecurity for Poultry* (Brunet) and *Selection and Use of Disinfectants in Disease Prevention* (Meyerholz and Gaskin).

[b] Where product types or names appear, no discrimination is intended and no endorsement or over other products not mentioned is implied by the U.S. Animal Health Association (USAHA). Mention of a trade name does not constitute a guarantee or warranty of the product by the USAHA.

[c] unless hard water is alkaline

[d] Use at less than 110°F, active principal driven off by heat.

[e] Hypochlorites: No chloramines: Yes

[f] Products listed are intended as examples; many other products are not listed. New quaternary ammonium disinfectants exist.

SALMONELLA RISK REDUCTION IN THE PRODUCTION OF BROILERS

VECTOR CONTROL BROILERS, PULLETS, BREEDERS

Vector control goes beyond preparation of depopulated houses prior to cleaning and disinfection. It also is an absolutely essential risk reduction practice for the entire life of your broilers.

Routine, licensed professional rodent and insect detection/extermination is suggested. Be sure that personnel practice strict biosecurity procedures for their clothing, equipment and vehicles and that the service provider has a good vector control record with poultry operations. A well illustrated, detailed publication, *Integrated Pest Management for Poultry*, (Arends and Stingham) is available free of charge. To order, refer to Appendix. Purina Mills has produced a film illustrating unique techniques for rodent monitoring and control.

I. **Rodents**

Rodent feces contain infectious doses of salmonella, particularly *S. enteritidis*, *S. typhimurium* and *S. arizonae*. Mouse pellets are commonly deposited in feed troughs and this is believed to amplify salmonella contamination in confined poultry. Beyond their salmonella amplification role, rodents appear to carry infection to other houses and farms.

Consequently, salmonella risk reduction should include (1) attempts to make all facilities rodent-proof, (2) proper selection of baits and bait placement, (3) prompt, secure disposal of any dead birds, or unused or spilled feed, and (4) regularly repeated professional rodent inspections, baiting and trapping. A detailed rodent control program follows.

II. **Rodent Proofing**

A. Eliminate potential rodent harborage inside and outside the poultry house (e.g. high grass, shrubs, garbage, broken equipment, construction debris, burrows under the foundation, and cardboard boxes).

B. It is suggested that some type of rodent barrier be installed around the perimeter of poultry houses.

C. Seal all entrance holes inside and outside the building. Repair siding and close siding seams. Doors and doorframes should fit snugly.

D. Seal holes and broken concrete. The use of "steel wool" to block a hole with masonry final coat is a method to insure no re-entry or exit.

E. Feed bins and buildings should be secured at night. Dispose of dead birds daily.

III. **Preparations for Baiting**

A. After house depopulation, all feed should be immediately removed from feeders and building so that rodents will promptly go to the bait.

B. Remove all alternative food sources for rodents, (e.g., spilled feed and dead birds).

C. Inspect the outside of the building routinely for rodent holes and burrows.

IV. **Bait Selection and Placement**

A. Warfarin, diphacinone, or pival are "multiple-dose" type anticoagulant rodenticides. They require continuous feeding over several days to have any lethal effect. They are best used as a routine every two-week baiting program. Newer anticoagulants contain brodifacoum and fromadiolone which may cause death 3 – 5 days after a single feeding. Such "single-dose" rodenticides can be used at any time and are especially appropriate immediately upon house depopulation. Tracking powder is especially useful for areas difficult to bait, but frequently used as passway by rodents (e.g. joists and rafters). Alternating rodenticides every 2 months has been found helpful by some in preventing bait shyness and rodenticide resistance. A list of rodenticides for use in poultry buildings can be found in Table 1.

B. Purchasers of rodenticides often under estimate the long-term need. Secure an adequate inventory.

C. Save bait by baiting only active holes. Fill all rodent holes with dirt or paper and then bait only those that have been reopened.

D. Place bait according to directions supplied by the manufacturer of your rodenticide. Place small amounts of bait frequently (up to 2X/wk) rather than large amounts infrequently. Rodents prefer fresh bait.

E. Control of attic rodents is facilitated by construction of a hatch for attic access and at least once yearly baiting with high wax, single-dose bait in throw packs as often as needed. Bait the outside perimeter of the poultry house with high wax bail as needed.

F. Once control has been achieved, inspection and service of permanent bait sites is essential every two weeks. Record the location and numbers of trapped mice and maintain these records. Inspecting premises with a low intensity red flashlight is an effective method of measuring control.

G. Caution: All baits are poisonous to rodents, poultry, other animals and people. Place baits carefully to prevent contamination of feed or accidental access by poultry and humans. Baits should not be placed loosely on the ground in areas frequented by people who might carry it on shoe soles and contaminate sensitive areas.

Table 1. Rodenticides for Use in Poultry Buildings

Common Name	Single/Multiple Feeding	Secondary Poisoning
Bromethalin	Single	No
Cholecalciferol (Vit.D.)	Multiple	No
Warfarin and Na-Salt	Multiple	Yes
Brodifacoum	Single	Yes
Bromadiolone	Single	Yes
Pindone and Na-Salts	Single/Multiple	Yes
Diphacinone and Na-Salts	Single/Multiple	Yes
Chlorophacinone	Single/Multiple	Yes
PMP-Ca-Salt	Multiple	Yes
Scilliroside	Single	No
Zinc phosphide	Single	No

EPA registered for use in agricultural buildings

V. **Insects**

A. Basic control strategy

The control of flies and beetles, which also may be salmonella vectors, requires use of a variety of practices. This reduces the selection pressure encountered with any single method. For example:

1. Keep litter well ventilated and dry.
2. Prevent water leaks and remove any wet areas.
3. If possible, use biological control methods (fly parasites and predators).
4. Use different classes of insecticides. Alternate, for example, between organic phosphates (Malathion), carbamates (Sevin) and pyrethrins. Diatomaceous earth may be used in conjunction with the chemical insecticides.

B. Insecticide Application

1. After the floor is dry following cleaning and disinfection, apply an approved insecticide to the floor, support poles and walls to control beetles and other inspect pests.
2. Synergized pyrethrins (Pyrethrin + piperonyl butoxide) are among the few insecticides that can be utilized in automatic spray systems inside poultry houses. Their advantages are: ability for quick "knockdown" of flying insects; short residual times; and low mammalian toxicity. The rate of application of such insecticides, particularly when applied by an automatic spray system should be no more frequent than twice a week.
3. Follow all manufacturer-recommended safety precautions when applying insecticides.

VI. **Wild Birds and Pets**

Avoid feed spills outside buildings and clean up immediately if they occur. Buildings should be constructed not only to exclude wild birds but to avoid birds perching under eaves or on blinds. Allow no stragglers to live after depopulation. Prevent wild birds from nesting and reproducing in the chicken house. Pets should be banned from poultry houses.

KEEPING PATHOGENS OUT OF THE POULTRY FARM

The biosecurity program described above to clean and disinfect the poultry house (farm) must now deal with "What comes through the security gate or fence."

The entire disease control program is based upon placing chicks free of certain diseases onto a farm also free of these disease pathogens and preventing the introduction of those same pathogens. A certain risk is associated with the movement of chicks, feed, people, vehicles and equipment onto the "clean" farm.

CHICKS

Chicks being placed on the farm should come only from breeder flocks tested and certified free or clean from specific diseases. In most countries these diseases include Pullorum, Typhoid, MG and *Mycoplasma synoviae* (MS) and more recently SE. Whenever possible farms should be all-in all-out single age flocks.

HATCHERIES

The hatchery is the central hub of all integrated meat-bird operations. Since all of the chicks pass through here, it is the one place where transmission of pathogens can reach every chicken house in the company. Poor biosecurity may also permit spread back to breeder flocks.

Infectious agents such as MG and Salmonella can be transmitted vertically from infected breeder flocks or the agents may enter the hatchery with people or contaminated vehicles or equipment. Hatchery biosecurity procedures should detect these infections early and either prevent their introduction or limit the horizontal spread if it does accidentally get introduced.

Like breeder farms, hatcheries provide the highest level of biosecurity for hatching grand parent and multiplier-breeder eggs. The grandparent hatchery should have a perimeter fence with only company egg-collection and chick delivery trucks permitted to enter, and only after cleaning and disinfection. Workers and visitors should park outside of the fence, be required to sign a logbook and shower before changing into hatchery clothing. For multiplier breeders and commercial broiler hatcheries, all employees and visitors should change outer clothing and footwear. However, showers should also be available in case of a disease outbreak. All egg-collection and chick delivery vehicles should be dedicated and fumigated daily.

The design of the hatchery should provide cleanable non-porous surfaces, slightly sloping floor to facilitate frequent washing and disinfection. Work flow patterns should only move from the clean egg room toward the dirty chick processing room. Air flow should be under positive pressure in clean areas with lower pressure in the dirty areas.

Setters should be cleaned and disinfected daily and after each transfer. Hatchers should be cleaned and disinfected after each hatch.

Periodic microbiological monitoring at the hatchery provides a quality assurance for the entire sanitation program. It may also detect breeder flock salmonella infections.

FEED

Feed and its delivery represent a significant risk to the biosecurity of poultry farms. A separate biosecurity program with its own good management practices is required for feed mills. Feed is a well known source of *Salmonella*, as well as other bacteria and mycotoxins, and must be handled properly, treated to eliminate pathogens and not allowed to be recontaminated after treatment.
Since all of this is out of sight of the poultry farm, the feed mill program must be known by the management responsible for biosecurity.

The design of the feed mill should provide for a separate ingredients side and a finished feed clean-side. The management must then control product flow and movement of people. Rodents and wild birds need to be excluded to prevent the introduction of pathogens into the normally clean grain stores or finished feed. Animal by-products such as fishmeal and meat and bone meal are higher risk ingredients. These should be moved and stored in separate bins by separate equipment. Monitoring these products for contamination and obtaining them from companies with good management practices of their own will reduce the load of Salmonella going into the feed.

Recognizing the risk of contaminated ingredients, the practice of pre-conditioning and pelleting and conditioning and acidification of finished feed is widely practiced. Monitoring for time-temperature in the pelleting process and measuring the level of acid added provides for quality control assurance. Now the clean finished feed must be kept from being re-contaminated by people, equipment use and vermin. In some countries where bag feed is used, the reuse of bags may be responsible for introducing pathogens to clean farms.

PEOPLE

The movement of people may represent the greatest risk for pathogen introduction into a poultry operation. No unauthorized person should be able to get anywhere near the chicken house or hatchery. Authorized company workers must be educated to the threat they bring with each entry to the farm. Shower-in procedures are essential for grandparent flocks, change of clothes, shoes, hat and hand wash at least for multiplier breeder flocks and coveralls, boots and hat with hand wash for broiler flocks.

Contact with other poultry is prohibited for company farm workers. This includes pet birds, fighting cocks, backyard birds, visiting live markets and hunting wild waterfowl. All of your good work may be ruined if one of these people can walk into a poultry house with a contaminated body, clothes or shoes. Service crews, vaccine crews, and caretakers move between houses and/or farms. They must understand the risk they bring. Feed truck drivers should never enter the chicken house. Mailboxes can be placed near the feed bin and used for feed delivery receipts. Egg pick-up drivers should only enter the outside entrance of the egg room

When possible, crews and service people should visit only one farm each day. It is best if caretakers live on breeder farm outside of fence. They should not visit other farms.

VEHICLES AND EQUIPMENT

Vehicles also move between farms. Their proximity to the poultry house should be limited. Parking too close to an infected poultry house may provide an opportunity for dust to contaminate both the outside and inside of the vehicle if the windows are left down. Contaminated feet may contaminate the floor of trucks and cars. Boots should be washed and sanitized before entering vehicles and shoes sprayed with disinfectant. Coveralls should stay on the farm or stored in plastic bags for cleaning. Flies may also be a problem and often "hitch a ride" in vehicles to the next farm.

Vehicles should be washed and cleaned thoroughly each week, more often if visiting a problem farm. Wherever possible, equipment should not be shared between farms, particularly grand parent and parent farms.

NATIONAL DISEASE CONTROL PROGRAMS

The evolution of biosecurity programs occurred because of the need to maintain breeder flocks free of *S. pullorum* infection. In the late 1920's and early 1930's, *S. pullorum* was a serious disease of young poultry that resulted in high mortality. Recognition of the important role of infected breeder flocks and its transmission to their progeny over long periods of time led to the development of a pullorum eradication program.

This program was based on blood testing and microbiology to identify pullorum infected birds. It was expensive and time consuming, so once you had a clean flock, you certainly wanted to keep it from being re-infected. A process we now call biosecurity.

In the United States, The National Poultry Improvement Plan (NPIP) was established in 1935 to provide for a national program to eradicate pullorum disease from breeder flocks. This plan is administered by the federal government through state government programs. It is voluntary and requires specific biosecurity-best management practices, specified periodic blood testing and microbiological testing. It is directed at foundation breeder stock and grandparent flocks, but may also include multiplier breeders if requested by a poultry company. NPIP also requires that diseases included in their program be reportable in each state. In this way, recognition of infection by diagnostic laboratories comes to their attention through state disease reporting systems.

NPIP is controlled by voting delegates from each state that is in the plan. Meeting every two years provides a forum for discussing and making changes in the program. Over the years, the program has expanded by poultry industry request to include *S. gallinarum* (typhoid), MG and MS. A major change was made in the late 1980's to include

paratyphoid salmonella because of the concern and public attention to food borne salmonella causing disease in people.

In the 1990's, NPIP was asked to certify product for export free of pathogens other than egg-transmitted SE or hatchery disseminated disease.

The basic NPIP program works because it is voluntary and it prohibits transport of birds across state lines for flocks failing to meet required standards. It does not absolutely require destruction of flocks. Thus no compensation must be paid. In reality, it also works because poultry companies in the program are also prohibited from doing business with companies not in the plan and the poultry industry would not purchase infected birds anyway.

This permits the company, located within a single state to provide chicks only to their own company farms, but not to other companies and not for the export market which has become very important. In the situation where a multiplier breeder flock were to become infected with MG, the company would not be required to kill the flock. Until recently, all of the companies I know of would in fact kill MG infected multiplier flocks. Since multiplier breeder flocks are not required to test and if a number of these flocks become infected, some companies have elected to keep the flock, medicate it to reduce the shed of MG to progeny, increase biosecurity of the infected farm, hatchery and broiler farms receiving their chicks.

This multiplier breeder farm would under-go extraordinary cleaning and disinfection prior to placing clean birds back on this farm. It would also undergo extensive serological monitoring to make sure it did not become infected again.

One company with wide spread MG infection in its multiplier breeder flock elected to use MG vaccine for a year to get free of the MG problem. The costs of killing all of these flocks could not be justified. The problem in this company was inadequate testing and poor biosecurity which permitted the MG to spread back to other breeder flocks.

Grand parent flocks and foundation breeders that become infected with MG would always be killed by the company at their own expense. They simply could not stay in business producing an MG infected chicks and they are required to be in the NPIP program to move birds or eggs across state lines. A similar response would occur in most Western European countries. Grand parent breeder flocks would be killed without compensation and multiplier breeders could be treated and allowed to live.

It would appear that the extraordinary effort spent by the breeder industry is still their burden. The meat bird industry chooses to live with MG at some level, but is willing to require breeders to stay free of this disease. Similarly the egg-type poultry industry demands that all levels of breeders, including multiplier breeders remain free of MG, but at the commercial egg production level there is still a high rate of infection.

In countries with modern poultry industries, national programs have eradicated and controlled pullorum and typhoid at the breeder and production level. Infection with these pathogens is not tolerated. MG and MS while not tolerated at the grandparent breeder level and above, still occurs occasionally at the multiplier breeder level. Required monitoring has worked well to identify infected flocks.

The addition of the human pathogens to these national programs has occurred with reluctance by the poultry industry. These salmonella, for the most part, do not cause significant disease in poultry. The poultry industry argues that these safety issues occur in food handling and cooking and should be the responsibility of these people. New government intervention at the farm level requires the poultry industry to be part of an overall salmonella reduction program.

SE has become the most common salmonella associated with food-borne illness in much of the United States and Europe. The result has been more regulatory programs to control, reduce or eradicate salmonella from poultry. In some countries, *S. typhimurium* is also included, and in a few other countries such a Sweden, poultry meat must be free of salmonella.

Because *Paratyphoid Salmonellae* infect almost any warm or cold blooded animals, the source for infecting poultry are numerous, unlike *S. pullorum* which infects only birds. Therefore the biosecurity required is significantly greater. The source for an outbreak at the farm can come from people, pets, snakes, other farm animals, rodents and wild birds. While feed ingredients are almost never contaminated with *S. pullorum*, they are commonly contaminated with other salmonella. Since the poultry industry is in the human food business, it is now also in the human health business.

Governments have responded differently to the salmonella problem. In the United States and Western Europe, monitoring is required for salmonella in both meat and egg-type chicken breeders. Flocks found to be infected are subject to government intervention. In the United States, salmonella infected multiplier breeder flocks and above are killed by the companies without compensation. In my experience, egg-type day old chicks found by my lab to be salmonella infected, results in the refusal to pay for the chicks and demanding compensation from the breeder company for the cleaning and disinfection required before the next flock can be housed.

The SE phage type-4 infection of both chickens and people was more serious. This particular phage type seemed at first to be much more pathogenic. The government in the United Kingdom required testing and slaughter of flocks found to be infected. They also compensated the owners for the birds. After almost ten years, the SE problem in the United Kingdom is much improved. The government now also allows for treatment of flocks as an alternative to slaughter then they do not have to pay compensation.

The most radical approach to the salmonella human health problem has been used in Sweden. They require that breeding stock be raised in quarantine and proved to be salmonella free of all salmonella. All broiler flocks are sampled prior to slaughter. Even

a single isolation of salmonella requires the entire flock to be destroyed. Additional checks are done at slaughter and finding of any salmonella causes the lot to be condemned. The Swedish poultry industry is small, the cost of production high, but the markets are protected from import by the requirements for salmonella free product. Compensation is paid through an insurance program that is affordable because of being able to recover costs in their controlled market.

THE FUTURE FOR BIOSECURITY AND MONITORING PROGRAMS

In the future, I believe the NPIP Program in the United States, and similar programs elsewhere will have two missions. Emerging new diseases that are transmitted from infected breeder flocks will be added to the program. The recent identification of the *"J"* avian *leukosis* virus is a good example. This is a serious disease problem that lends itself to this program. First it will require a simple test that can be done in state laboratories.

Second, the ever increasing emphasis on food safety will require that more effort to reduce the prevalence of human pathogens in poultry. Campylobacter infections in people have been recognized for some time as a common cause of gastrointestinal disease and poultry is the most common known source. Surely a new program will be directed toward the control of campi.

The best way to accomplish these goals is by involving poultry industry representatives, academia and government officials in developing new programs. Government regulations without concurrence by the poultry industry may fail.

The development of the voluntary Pennsylvania Egg Quality Assurance Program (PEQAP) by the egg layer industry, academia, state and federal government resulted in a workable and affordable new program. The Pennsylvania egg industry in 1988 suddenly found itself involved in food-borne outbreaks that were traced back to their flocks. During the course of several years, government and academia supported research found that some of these flocks were responsible for the outbreaks. We also developed new biosecurity and monitoring programs for the egg industry. The Pennsylvania program has reduced its infected flocks down from 48% to 7% and this rate continues to drop. This program only works because the industry was part of the solution. I hope the method of development of PEQAP can be a model for future government-industry programs.