

# **MANAGEMENT STRATEGIES FOR HEALTHY FEET**

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## **INTRODUCTION**

The majority of lameness in dairy cattle is related to claw disorders, primarily sole ulcers and white line disease. These conditions are predisposed by laminitis and housing conditions that encourage hoof overgrowth and weight-bearing disparities, or in some cases, excessive rates of hoof wear. Preventing or limiting these problems requires proper attention to nutrition and feeding management and optimization of cow comfort. Beyond these, herds must incorporate facilities for examination and treatment of lame cows and develop protocols for timely maintenance and corrective trimming. Footbaths may provide some assistance for the management of infectious claw disorders, but when used as the sole method to provide control of these conditions results vary from adequate to poor. Optimal treatment and control generally requires a combination of topical spray treatment, individual bandaging or wrapping, and use of a well-managed footbath. The one sure bet is that no matter how well cows are fed or housed, a certain amount of lameness is inevitable.

## **LAMINITIS AND ITS RELATIONSHIP TO CLAW DISEASE**

The pathogenesis of laminitis is believed to be associated with a disturbance in the micro-circulation of blood in the corium which leads to breakdown of the dermal-epidermal junction between the hoof and P<sub>3</sub>. Rumen acidosis is considered to be a major predisposing cause of laminitis and presumably mediates its destructive effects through various vasoactive substances that are released into the blood stream in coincidence with development of rumen acidosis. These vasoactive substances initiate a cascade of events in the vasculature (network of blood vessels) of the corium including increased blood flow, thrombosis (clot formation), ischemia (lack of blood flow), hypoxia (lack of oxygen), and arterio-venous shunting (which directs the flow of blood directly from artery to vein). The end result is edema (swelling), hemorrhage (bleeding), and necrosis (death) of corium tissues.

By virtue of its anatomical location between the hoof shoe and P<sub>3</sub> the corium is particularly vulnerable to inflammatory insult. Any increase in size of the corium due to fluid accumulation (blood and lymph) will increase pressure, pain, and tissue damage. Bound on one side by the hoof

wall and the other by the P<sub>3</sub> inflammation of corium tissues often leads to swelling at the coronary band.

Destruction of the dermal-epidermal junction has particular consequences as it permits laminar separation. As the laminae separate P<sub>3</sub> begins to "sink" within the hoof horn shoe. The result is compression of the corium between the P<sub>3</sub> and sole which sets the stage for the development of sole ulcers. In some cases this "P<sub>3</sub> sinking phenomenon" involves severe rotation of the toe of the P<sub>3</sub> downward toward the sole. If compression of the corium by the toe is severe enough a toe ulcer may develop. If, on the other hand, sinking of the P<sub>3</sub> is such that the rear portion sinks furthest, compression and thus sole ulcer development will most likely develop in the area of the heel-sole junction (known by some as the "typical site" or the site most commonly associated with the development of sole ulcers).

### **SOLE ULCER**

A sole ulcer is described as a circumscribed loss of the horny sole which exposes the corium. Sole ulcers tend to be one of the most debilitating of lameness conditions affecting dairy cattle. Early ulcers may appear as nothing more than a circumscribed area of fresh tissue that may be uncovered in the process of hoof trimming. More mature or long-standing sole ulcers may be covered initially by rough, irregular horn tissue that when pared away exposes granulation tissue which bleeds freely if damaged.

As indicated, laminitis is thought to be a major predisposing cause of sole ulcers. The combination of excessive hoof horn formation, displacement of the pedal bone, the production of softer solar horn, and the accelerated growth of hoof horn on the anterior (front) and abaxial (outside) hoof walls predispose the lateral claw to excessive loading, wear, and weight-bearing at the "typical site". The additional strain and pressure applied to the heel/sole region (or toe in the case of toe ulcers) exacerbates dysfunction of the underlying corium and leads to development of the lesion. Treatment requires removal of the necrotic (dead or decaying) horn tissue followed by elevation of the affected claw with a footblock attached to the unaffected claw. All healthy horn tissue should be left in place (See Steps 5 & 6 under Claw Trimming and Foot Care).

### **WHITE LINE DISEASE**

Areas of hemorrhage are often most noticeable and severe in the white line region of the sole. This corresponds to the primary weight-bearing region of the claw. Because it is an active area of hoof horn formation (laminar horn) it is also highly vascular, and a frequent site for hemorrhage during bouts of laminitis. These areas of hemorrhage are not visible during the acute stage of laminitis, but instead, gradually rise to the surface of the sole over a period of 4-8 weeks. At this point they become visible and useful as indicators of previous disease of the corium (subclinical laminitis).

Another outcome of veterinary significance associated with laminar necrosis and white line separation is the formation of subsolar abscesses (otherwise known as white line disease). There are a couple of reasons for this: 1) dermal-epidermal separation and distorted claw growth results in widening of the white line, and 2) laminar horn of the white line formed by the diseased corium is softer and thus more subject to wear, separation and penetration by foreign material from the environment. As a consequence, the incidence of white line disease increases in herds suffering from laminitis.

White line lesions/abscesses are treated by paring away all loose and damaged horn adjacent to the lesion (See Steps 5 & 6 under Claw Trimming and Foot Care). Care should be taken to establish drainage, however minimize peripheral damage. A foot block should be applied to the unaffected claw to reduce weight-bearing and ease discomfort in the diseased claw. There is no need to bandage the lesion unless it is required to control bleeding. The same is true for antibiotic therapy unless the infection extends to deeper tissues of the foot as evidenced by swelling and severe lameness.

## **CLAW TRIMMING AND FOOT CARE**

### Claw Trimming

The fundamentals of hoof trimming are described by Raven (Raven, 1989). Readers are advised to consult this book for a more in-depth review of this topic. The following describes the basic objectives and trimming procedure.

The objectives of preventative hoof (claw) trimming are:

- Correction of the relative overgrowth that leads to overburdening of the claw (overgrowth is most significant for the outside claw of rear feet and the inside claw of front feet).
- Restoration of the appropriate weight-bearing surface within each claw.
- Correction of claw lesions at an early stage.

The following 6-Step work plan for trimming feet is recommended:

### Step 1

Judge the length of the claws. Since the inner hind claw represents the more normal claw, this claw is used as a model for the more abnormal outer claw. The front wall of the medial (inner) claw should be 3 inches long (from just below the coronary where the hard horn starts to the tip of the toe). This length of 3 inches (7.5 cm) is taken as the correct front wall length for the average Holstein-Friesian cow. Thickness of the sole should be a minimum of a 1/4 inch. Spare as much heel on the medial claw as possible so that weight may be transferred to this claw in the event of a lesion occurring in the outer claw.

Next, reduce the length of the inner claw to the required length. The bearing surface (sole and wall but not the heel) is “stabilized” on the inner hind claw. In other words, the bearing surface of the toe and wall is pared flat so that it will be at right angles to the long axis of the shin (cannon) bone in the

standing position. This will ensure that the cow has a flat and stable supporting weight-bearing surface on hard ground.

The heel of the inner claw is not trimmed down unless overgrown. Furthermore, since claw lesions in the outer claw are the more frequent circumstance, preservation of the heel on the inner claw is desired in the event that it is necessary to provide rest to the outer claw by increasing weight-bearing on the inside claw heel.

A proper front wall length (at least 3 inches) will ensure adequate sole thickness particularly at the toe where sole thickness of at least a 1/4 of inch (5-7 mm) is required. The sole in this area should not “give” under pressure. If it does it may indicate that the sole has been trimmed too thin. Thin soles subject the underlying corium to bruising or a greater potential to wear through, particularly at the white line. Exposure of the corium often leads to grave consequences for the foot.

### Step 2

Using the medial claw just trimmed as a guide, trim the toe of the outer claw (rear foot) to the same length. Next, pare the weight-bearing surface (of the sole) of the outside claw to the same level as that of the medial claw. The outer claw is trimmed to the same level as the inner claw both at the toe and at the heel. Leaving a damaged outer claw higher than the inner claw will probably lead to lameness. It is for this reason that the inner claw heel is preserved. When complete the weight-bearing surfaces should be flat at the toe.

### Step 3

Shape and slope the sole so that the innermost back portion of the sole slopes toward the center of the claws. Care should be taken to avoid paring away important weight-bearing surface at the toe. Excessive cupping or sloping of the sole should be avoided because it reduces the weight-bearing surface area to the outside walls. This is one of the most common errors in foot trimming. Proper sloping of the sole in this region is designed to reduce pressure in the sole-ulcer site area and open the interdigital space between the claws. Overgrowth of the sole which occludes the interdigital space causes dirt and manure to be entrapped between the claws. This increases the likelihood of interdigital disease.

### Step 4

Balance the heels. Weight-bearing surfaces should be flat at the toes, along the walls, and across the heels. This assures an appropriate distribution of weight within and between the claws and completes the trimming process in feet where further corrective trimming procedures are unnecessary.

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Steps 5 and 6 are characterized as “therapeutic and curative trimming procedures”. They are applied as needed.

### Step 5

Pare the damaged claw lower toward the heel to increase weight-bearing on the healthy claw. In most cases the damaged claw will be the outside claw of rear and the medial claw of front feet. Specific indications for this trimming procedure would include conditions in which overgrowth has

led to overloading (i.e. hemorrhage at the sole ulcer site) or excessive weight-bearing on the claw. Lowering the damaged claw reduces weight-bearing and thereby permits recovery and eventual return to normal function and health. In some cases it is necessary to apply a footblock to the healthy claw in order to reduce weight-bearing in the damaged claw.

### Step 6

In the presence of hoof horn lesions, further corrective trimming is necessary. Remove all loose horn irrespective of how extensive it is (sole separation) and pare away hard ridges (heel horn erosion). Only healthy hoof horn should be left in place.

Never dig holes. Always slope horn towards the lesion. For example, trim the area around sole ulcers and remove the lateral wall when trimming out white line lesions. Trim carefully and DO NOT remove new healthy horn. Avoid damage to the corium (ie. stop when trimming leads to bleeding of the corium).

Do not trim horn with cracks or hemorrhage of the sole excessively; unless there is pain or swelling. Once necessary horn removal has been accomplished, avoid cutting away more horn at each examination unless conditions (ie. loose or damaged horn) warrant such measures.

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Part of fixing a foot is trimming a foot. In other words, unless the defect that created the problem is corrected the benefits from curative procedures are short-lived. The step-wise procedure as outlined above, if followed, forces one to observe and trim the healthy as well as the lame foot in a lame cow. Quite often, similar problems can be found in the other foot. Cows that do not respond or get worse within a couple of days should be re-examined.

### Facilities and Equipment for Foot Care and Claw Trimming

In most herds the single greatest impediment to providing timely care of foot problems is a lack of restraint facilities to permit proper examination and treatment. Consequently, the first step toward establishing a foot care program is to invest in restraint and handling facilities. Stand-up-type chutes or tilt tables specifically designed for foot care are the best options. Prices vary from \$1000 or less to near \$30,000 for a fully hydraulic restraint system. Each restraint device has advantages and disadvantages. The choice is largely one of personal preference. An Austrian study found no benefit of one over another (Stanek, et al., 1998). Both the tilt table and stand-up chute restraint systems induced fear and anxiety in cows. It would appear that quiet and gentle handling coupled with efficiency are of greatest importance.

Hoof knives and a good set of nippers are the primary tools required for claw trimming. Power tools such as rotary (angle) grinders are used by experienced persons, however because these are designed for rapid removal of hoof horn they must be used with extreme care. Another item that trimmers find useful is a hoof tester. This is used to find painful areas in the claw that may require closer examination. In addition to these, all hoof care areas must have sharpening equipment (files or grinders), foot blocks and appropriate accompanying adhesives, and topical treatment and bandaging materials.

### Personnel Training in Foot Care and Claw Trimming

Large herds (300 cows or more) should consider training personnel on the farm to fix and trim feet on a regular or daily basis. This will assure timely care of lameness conditions and prevent the loss of cows from irreversible foot disease. Options for formal training in foot care and trimming procedures are relatively few. One such program has been developed at the University of Florida by a grant from the Florida Dairy Industry (Van Amstel and Shearer, 1998). That program, the Master Hoof Care Program, is designed to train farm technicians in the art and science of foot care and claw trimming. To date, nearly 150 people have taken the 3 ½ day course, and, of those approximately 10% have passed the written/oral and practical examinations to become qualified as Master Hoof Care Technicians.

## **INFECTIOUS CLAW DISEASES**

Infectious claw disorders represent some of the most important causes of lameness in dairy cattle. However, unlike the lesion associated with a sole ulcer or white line disease which specifically affects the claw, these diseases affect the “skin” of the interdigital space, heel bulbs, and interdigital cleft (on the back of the foot above the interdigital space). Although there are some differences in the way these conditions develop and the way they appear, they all have at least one thing in common: they are believed to be caused by infectious agents capable of inducing inflammation and lameness.

### Papillomatous Digital Dermatitis (PDD), also known as Hairy Heel Warts

This disease has occurred in near epidemic proportions throughout the United States since the early 1990s. Although not conclusively proven, it is the opinion of most that footwarts are caused by 3, or possibly 5, different bacterial spirochetes belonging to the genus *Treponema sp* (Choi et al., 1997). Although lameness caused by footwarts may be severe, it tends to be an inconsistent feature of this disease. Florida studies indicate that only about half of the animals affected exhibit lameness (Shearer and Elliott, 1998; Shearer et al., 1998). Cows naturally avoid contact with the ground or flooring surface by walking on their toes. In fact, stubbed toes from excessive hoof wear is one indicator of a footwart problem in cows. Despite obvious indications of discomfort, research indicates that cows affected with PDD are likely to suffer reduced reproductive performance and a tendency for lower milk production (Argaez-Rodriguez et al., 1997).

Approaches to therapy of PDD include: 1) surgical excision (removal), 2) footbaths, 3) topical treatment with various disinfectants, caustic chemicals, and antibiotics, 4) cryosurgery (freezing), and electrocautery (burning), 5) topical treatment under a bandage, and 6) systemic antibiotic therapy (Shearer and Elliott, 1998). Most of these treatments have a place in the management of this condition, however the less invasive forms of treatment are preferred by these authors and highlighted in the following.

Topical spray-on treatment with antibiotic and some non-antibiotic preparations has been shown to be very effective when used in a scheme of consistent daily treatment for a period of 8-10 days over a 2-week period (Hernandez et al., 1999). The major disadvantage to topical treatment is that lesions occurring in the interdigital space are missed. Topical treatment under a bandage is

particularly effective with most cows showing remarkable improvement within 24-48 hours. Furthermore, when properly applied this approach to treatment has the advantage of reaching interdigital lesions. Theoretically at least, the same is true for well-managed footbaths. Unfortunately, there are no published data on the effectiveness of footbaths for control of footwarts.

### Interdigital dermatitis (ID)

Interdigital dermatitis is an acute or chronic inflammation of the interdigital skin, extending to the dermis (deeper layer of skin containing blood and nervous tissue). The disease is likely caused by a mixture of bacteria: *Fusobacterium necrophorum*, bacterial spirochetes, and possibly *Dichelobacter nodosus*. In the early stages, ID is characterized by superficial erosion of the interdigital skin that some are able to recognize by its distinctive foul odor. The interdigital lesion is usually painful to the touch and followed by extension of the infection to the heel horn that results in heel erosion, the most readily visible feature of this disease. Early on the eroded heel horn develops a pitted appearance. Eventually the roughened pitted heel horn is replaced by fissures (horizontal cracks) which may be sufficient to result in severe undermining of heel and solar horn. Coincident with this heel erosion is an acceleration of hoof horn formation. Excessive hoof formation leads to overgrowth and overloading of the affected claws. It's these effects of ID that are believed to make it an important predisposing cause of claw disease problems, particularly sole ulcers (Raven, 1989). Effects of ID on the interdigital skin are similar. Chronic inflammation causes the interdigital skin to thicken eventually resulting in the formation of an interdigital fibroma or "corn". The clinical diagnosis of ID is based on the presence of a thickened interdigital skin, pungent characteristic odor, pain to the touch, and the concurrent presence of heel horn erosion.

Unlike footwarts, because of their location in the interdigital space, most lesions of ID are not accessible to treatment by topical spray. Furthermore, the specific treatment of heel horn erosion by topical spray has not been thoroughly studied. Instead, topical treatment under a bandage and footbaths are the likely the best options for treatment of interdigital lesions in cows.

### Footrot and Super Footrot

Footrot is an infectious disease of the interdigital skin characterized by the presence of an interdigital lesion, swelling, and moderate to severe lameness. Fever ranging from 103-105°F (occasionally higher) is a consistent finding during the acute stages. Although evidence is inconclusive, most believe that footrot develops following injury or abrasion of the interdigital skin. This interdigital injury is secondarily infected by *Fusobacterium necrophorum* alone, or in combination with *Bacteriodes melaninogenicus*, organisms which encourage progression to a more severe and necrotic-type of lesion. Failure to institute treatment early in the course of the disease may lead to complications involving surrounding soft tissues (tendons, tendon sheaths, joint capsules, and bone) ultimately resulting in deep digital sepsis. At this stage, response to medical therapy is quite often unrewarding, thus limiting one's options to either surgery, or possibly euthanasia, in particularly severe cases.

In recent years, clinicians from the United Kingdom and the United States have observed a more extreme form of this disease referred to as "super footrot". It is characterized by acute onset of

lameness and swelling of the foot that progresses rapidly to an ascending cellulitis (a spreading infection). The interdigital lesion associated with this form of footrot tends to be especially severe and successful treatment particularly challenging. Readers are advised to contact their veterinarian for specific advice on treatment options if they suspect this form of the disease.

Footrot is responsive to most antibiotics in common use for cattle. In fact, dose and duration of treatment are likely more important than antibiotic selection. The key to achievement of a successful therapeutic outcome is dependent upon prompt recognition and early implementation of treatment procedures. Systemic therapy plus topical treatment of the interdigital lesion have long been the preferred methods of treatment. In uncomplicated cases, improvement is noticeable within 24-48 hours with good recovery attainable in 3-4 days from the onset of treatment. Treatments of choice are Naxcel (Ceftiofur Sodium), Penicillin, Albon (Sulfadimethoxine), and tetracyclines (extra-label in dairy cattle). Some prefer to simultaneously treat the interdigital lesion as well. Various antiseptic-type products may be used as topical treatments. Bandaging of the foot is unnecessary. Regardless, the secret to success is early detection of the disease.

### **FOOTBATHS AND ENVIRONMENTAL CONSIDERATIONS**

Although efficacy data are relatively non-existent, some recommend the use of a walk-through footbath containing 3-5% formalin, antibiotics, or 5% copper sulfate (See Appendix 1). To maximize effectiveness, it is suggested that a pre-bath of plain water be used ahead of the medicated footbath. Purpose of the pre-bath is to remove organic matter from the feet thus reducing contamination of the medicated bath and extending its usefulness. Some recommend placement of footbaths in parlor exit lanes, however, in some operations cows tend to loiter in lanes exiting the parlor. In general, it is best to locate footbaths in pathways or areas where cows tend to keep moving. After traversing through the baths, if possible, cows should be kept in a clean dry area for approximately 30 minutes. This allows time for drainage of the excess fluid and for the medications to exert their antibacterial action.

In addition to their germicidal effects, formalin and copper sulfate aid in hardening the claw horn and skin. In particular, readers are cautioned that formalin is dangerous to handle and can cause serious eye, skin, and respiratory injury. Formalin should not be used in concentrations exceeding 5% or for longer than three consecutive days.

Interdigital dermatitis occurs worldwide and is believed to be associated with conditions that create a moist claw environment combined with exposure to manure and slurry. The incidence of ID seems to be particularly high in confinement-type housing conditions. Risk factors for PDD (footwarts) are greatest for large herds, and herds that purchase or raise the majority of replacement animals at off-farm locations. As with ID, proper management of manure and slurry is believed to be an important control measure. Wet and muddy conditions appear to be significant risk factors for both diseases.

### **IN SUMMARY**

The primary causes of lameness are claw disorders predisposed by laminitis and housing conditions that encourage hoof overgrowth and/or excessive wear. Infectious claw diseases represent significant causes of lameness as well particularly in confinement type housing systems. Since the proper examination and treatment of these conditions requires good restraint, all herds should develop facilities for the safe and efficient handling of lame cows. Training of personnel in appropriate foot care and claw trimming is essential. The 4-Step claw trimming procedure, adapted from Dr. Toussaint Raven, is one approach to the accomplishment of this task. Infectious claw disorders may be amenable to control by use of footbaths. These diseases are generally more effectively treated and controlled by applying a combination of topical treatments either under a bandage, as a topical spray, and/or possibly in a well-managed footbath. Footrot and “super footrot” represent conditions that cause severe inflammation and swelling of the foot. Prompt identification and antibiotic treatment are crucial to achievement of a successful therapeutic outcome with footrot. Interdigital and papillomatous digital dermatitis are similar conditions. Heel erosion, accelerated skin and hoof horn formation, lesions in the interdigital space, and the presence of bacterial spirochetes are consistent findings with both ID and PDD. Although lameness is inconsistent, lesions are painful and have a negative impact on overall performance. Footbaths are the traditional means to manage foot problems. Persons who rely on footbaths for control of infectious claw diseases should consider the following: the specific condition being treated or controlled, size of the herd, use of a pre-bath, proper placement or location of the bath, and contents or active ingredients used in the bath.

## References

1. Argaez-Rodriguez, R.J.D., W. Hird, J. Hernandez, D. H. Read, and A. Rodriguez-Lainz. 1997. Papillomatous digital dermatitis on a commercial dairy farm in Mexicali, Mexico: incidence and effect on reproduction and milk production. *Prev. Vet. Med.* 32:275-286.
2. Choi, B. K., H. Nattermann, S. Grund, W. Haider, and U. B. Gobel. 1997. Spirochetes from digital dermatitis lesions in cattle are closely related to treponemes associated with human periodontitis. *Int. J. Sys. Bact.* 47:175-181.
3. Hernandez, J., J. K. Shearer, and J. B. Elliott. 1999. Comparison of topical application of oxytetracycline and four non-antibiotic solutions for treatment of papillomatous digital dermatitis in dairy cows. *J. Am. Vet. Med. Assoc.* 214:688-690.
4. Raven, T: *Cattle Footcare and Claw Trimming.* 1998. Farming Press Ltd.
5. Shearer, J. K., and J. B. Elliott. 1998. Papillomatous digital dermatitis: treatment and control strategies - Part I. *Compend. Cont. Educ. Pract. Vet.* 20:S158-S166.
6. Shearer, J. K., J. Hernandez, and J. B. Elliott. 1998. Papillomatous digital dermatitis: treatment and control strategies - Part II. *Compend. Cont. Educ. Pract. Vet.* 20:S213-S223.
7. Stanek, Ch, E. Mostl, H. Pachatz, and A. Sixt. 1998. Claw Trimming, restraint methods and stress in dairy cattle. *Proceedings of the 10<sup>th</sup> International Symposium on Lameness in Ruminants, September 7-10, p. 13-16.*
8. Van Amstel, S. R., and J. K. Shearer. 1998. Approach to improve claw trimming in dairy cattle in the Southeastern United States. *Proceedings of the 10<sup>th</sup> International Symposium on Lameness in Ruminants, September 7-10, p. 17.*

## APPENDIX 1.

### FOOTBATHS

#### I. Copper Sulfate

- A. 5% Solution = 8 pounds in 20 gallons of water
1. Hot water hasten dissolving. Vinegar will aid dissolving in hard water. The solution must be kept reasonably clean since manure will de-activate it.
  2. Copper sulfate is irritating when used at high concentrations. One study suggests that copper sulfate may have deleterious effects on hoof horn. Concentrations greater than 10% are not recommended.
  3. Copper is toxic to sheep. Copper sulfate should **not** be used in footbaths intended for sheep.

#### II. Zinc Sulfate

- A. 20% Solution = 34 lbs. powdered, Agricultural grade zinc sulfate monohydrate (36%), per 20 gallons of water.
1. This is non-irritating to the feet and can be used daily.
  2. Effectiveness for controlling foot problems in cattle is unknown.

#### III. Formalin

- A. 5% Solution = 1 gallon of 36% formaldehyde in 19 gallons water.
1. It is very irritating when inhaled and should only be used or mixed outdoors. It is also irritating to the skin and feet and should not be used repeatedly as a footbath at greater than 5% concentration. Formalin tends to harden hooves with repeated use. Any residue solution should be discarded and a fresh batch mixed before each use to avoid mixtures which may become too concentrated from evaporation.
  2. Formalin is monitored by the Environmental Protection Agency. All suppliers and/or distributors are required to keep records of sales. No more than 500 lbs. should be kept on site at any one time.
  3. Human health risks are the greatest drawback. Formalin should be used with great care.