Artificial Insemination – An Overview of the Process in Cattle

Many producers of purebred and commercial beef cattle can profitably utilize artificial insemination (AI) on virgin heifers or on the cow herd or both. Success with artificial insemination requires attention to detail in all areas of herd management. One of the most important factors affecting the success of the program is the manager's attitude. He or she must totally desire to make AI work and instill this commitment into each link in the chain of management decision. The weakest link sets the level of success of the operation. Should any aspect of management become subpar, AI conception rates will be reduced, most likely to the extent it will cancel many of the benefits the technique offers. Many managerial decisions relative to feeding, facilities, fences and corrals, equipment, sire selection, will be necessary.
Both a sound health program and good nutrition are requirements of any breeding program but become an absolute essential ingredient for artificial insemination. In addition, more labor and skill are needed especially in the initial phases of the program.

Learning Artificial Insemination:

Supervised instruction and guidance are essential because without adequate training, valuable AI equipment and semen could be seriously damaged. In order to ensure high fertility, frozen semen requires very special storage and handling techniques. Adequate training is also essential to minimize risk of injury to either a valuable animal or to yourself.
AI Training Schools are available from several semen suppliers. The objective of these schools is to teach the skills required to handle semen, inseminate cows, and manage a successful AI program. Three basic areas of instruction should be provided by AI Training Schools including:

1. **Insemination technique**, developing through live animal practice, the ability to skillfully and accurately place semen at the proper location within the reproductive tract using sanitary and correct techniques.
2. **Semen handling**, developing through practice, the ability to properly handle, thaw and prepare semen for insemination, according to the recommendations of semen-producing organizations.
3. **Reproductive management** training in the importance of heat detection, herd health, and total herd management for the development and continued success of an AI program.

The National Association of Animal Breeders (NAAB) is an association of companies that service the artificial insemination business. NAAB has recommended minimum standards for AI Training Schools. Address inquiries to: Technical Director, National Association of Animal Breeders, P.O. Box 1033, Columbia, MO 65205. A potential student should ask if the school considered meets the following recommendations:

1. Six hours of live cow insemination practice done over a minimum of three separate sessions.
2. At least two cows per student per course, with each student having access to a minimum of ten practice cows.
3. A maximum of eight students per instructor. Do not expect an AI Training School to do it all for you. Supervised training is just the beginning; after that, continuous practice is necessary to fully develop the required skills.

Heat Detection and Beef AI Programs:

The most limiting factor in artificial insemination programs is the proper detection of cows or heifers in estrus. Estrus, or "heat", is that period of time that occurs every 18-24 days in sexually mature, non-pregnant female cattle when they are receptive to mounting activity by bulls or other cows. In beef cattle operations where artificial insemination is the means of breeding the females, the herdsman must recognize and interpret a cow's heat signals. Proper timing of the artificial insemination is necessary to accomplish a high percentage of conceptions in the cows that are bred artificially.

Considerable amounts of research have been conducted on the various factors contributing to the efficiency with which cows are detected in heat. When all is considered, one of the key factors is the skill of the human performing the heat detection. With an AI program, people assume the same responsibility as the bull for accurately detecting heat and the proper timing of insemination. Thus, the dilemma for the inseminator is determining which cows are in a "standing heat" and when that heat occurs.
A cow is fertile only when an egg has been released (or ovulated) from the ovary. This occurs about 10-14 hours after the period called "standing heat" ends. Because sperm need time in the cow's reproductive tract

before they are capable of fertilizing the egg, insemination should be made several hours before ovulation. This means that for the highest fertility, cows or heifers should be inseminated in the latter two-thirds of heat or within a few hours after having gone out of heat. This represents approximately 12-18 hours after the cow first comes in "standing heat."

Heat Detection Efficiency:

Heat detection efficiency (rate) is defined as the percentage of eligible cows that are actually seen or detected in heat. Several methods of calculating the efficiency with which heat is detected are available. A detection rate of 80-85 percent should be achievable. The detection rate can be measured by the 24-Day Heat Detection Rate Test, which is a test that the producer can implement to self-evaluate the heat detection efficiency (or inefficiency).

In order for cows to be included in the test, they should be eligible to have heat cycles, at least 50 days post-calving for beef cows; be free of reproductive disorders such as cystic ovaries, pyometra, or other reproductive tract infections; and be non-pregnant. In addition, cows must have adequate body condition to expect most of them to be cycling. What producers are looking for is a group of cows that are most likely to display estrus in the next 24 days. Some of these cows will in fact be serviced during that interval, which will exclude them from the next 24-day list. At the end of the 24-day period, the number of cows detected in heat is divided by the total number of cows eligible to have estrous cycles. If the producer observed 50 cows but only 15 were detected in heat in 24 days that is a 30% detection rate—not too good. If the producer finds 40 or more cows in heat during the 24-day test period for 80% or better detection rate, then a good AI program is possible.

Time	Percent cows showing heat signs
6 a.m.-noon	22%
noon-6 p.m.	10%
6 p.m.-midnight	25%
midnight-6 a.m.	43%

A second method of self-evaluation of heat detection can be performed by keeping an accurate record of heat dates. The average interval (in days) between detected heats is divided into the "expected" interval or 21 days. For example, if the average interval between detected heats for all eligible cows is 25 days, then the detection efficiency would be computed at 21/25, or 84%.

Heat Detection Requires Observation:

The surest sign of estrus is that of a cow or heifer that permits other animals to mount her while she remains standing. This is the best sign of a cow's fertile period. Therefore, the most productive means of determining which cows are in "standing heat" is to observe the cattle carefully for about 30 minutes at least twice per day. More frequent observations may also be beneficial whenever it is practical. Estrous synchronization will aid in accurate heat detection and shorten the number of days that heat detection must be done. Learn more about estrous synchronization by reading OSU Fact Sheet F-3163, "Estrous Synchronization of Cattle."

The best times of the day to observe cattle for heat detection are early in the morning and at the last daylight in the evening. However, heat detection while cattle are eating at feed-bunks or hayracks is difficult because hungry cattle are often more interested in the feed than in each other. Table 1 from Cornell University researchers describes the percentage of cows showing signs of heat at different times of the day. By far the largest percentage of cows exhibit signs of estrus at the least convenient time of the day for accurate heat detection. This fact alone is considered a major cause of heat detection inefficiency. Many of the cows that do have a "standing heat" from midnight to 6 a.m. can be observed as having "secondary" signs of heat at the time of normal heat-detection on the previous evening. The secondary signs of heat include (1) a willingness to mount other cows, even though neither cow may be willing to stand for the

mount, (2) roughened tail head or mud on the rump, which is evidence that other animals have tried to mount her, (3) restlessness, which may be indicative of a cow about to exhibit heat (cows in pre-heat may bawl more than usual, head-butt, pace the fence, sniff or lick other cattle) and (4) clear stringy mucus discharge which may be hanging from the vulva or smeared on the pin-bones or rump of a cow about to have estrus or one already in estrus. Bloody mucus often appears 2-3 days after estrus has occurred and should be recorded in order to closely watch for heat in 17-21 days.

Aids to Heat Detection:

Several aids to heat detection are available for producers with artificial insemination programs. These aids include chin-ball markers placed on androgenized cows or deviated "gomer" bulls. This is a device similar to a ball-point pen that is strapped on the underneath side of the chin of an animal expected to mount cows or heifers in heat. The ink in the chin-ball marker leaves colorful streaks on the back or rump of a cow that has been mounted or was attempted to be mounted. Another commercially available aid to heat detection is the "Kamar heatmount detector" (tradename). This device is glued to the rump (just forward of the tail head) of cows suspected to be in heat in the near future. Prolonged pressure (at least 3 seconds) from the brisket or chest of mounting animals will turn the originally white detector to red. Using the heatmount detector will be more effective in those pastures with little or no low-hanging tree limbs, brush, or backrubbing devices since false readings can occur.

An economical heat detection aid is used at many U.S. dairies. This method is called "tail-chalking" and involves only the small expense of an oil-based "sale barn" paint stick. The paint stick is available at many farm and livestock supply stores and comes in a variety of colors. Orange is often the color of choice, especially with producers who are color-blind.
The chalk (or livestock paint) is rubbed on the tail head of cows to be heat detected. The chalk should be placed from the imaginary line between the hook or hip bones back to and including the corner where the tail begins its vertical descent.

Some producers choose to chalk in a narrow strip in summer months (after shedding has occurred) and wider bands on winter hair coats. Most tail-chalking veterans put the chalk in a strip two to three inches wide. The length is important because of the different contact points possible when the cow is mounted. In the spring, when cows are shedding, it is just about imperative that the area be curry-combed so the applicator will deposit chalk instead of just rub off winter hair.
Beef cattle producers can tail-chalk cows, at about 50 days after calving, while the cows are crowded in a long working chute or alley. Replacement beef heifers could be expected to have a high percentage of cycling animals when they are about 13-14 months of age and weigh approximately 65% of their expected mature body weight.

Reading the chalk strip is not hard but does require close observation and some practice. When a cow is just coming into heat and is being ridden but will not stand, the chalk will be slightly smeared. Also, it will often have some of the riding animal's hair in it and both the hair and chalk will be ruffled forward, with a feathered appearance. When those conditions are spotted, write down the cow's number and watch her more closely.
When she is in "standing heat" and being ridden repeatedly, the chalk will be mostly rubbed off. This cow may have been in "standing heat" during the previous night. The cow should be watched to see if she does in fact allow other animals to mount her. If she does, then she is in "standing heat." If you do not observe the cow in "standing heat" but your barn records indicate that it is 18-24 days since she was last observed in heat or bred, then it is time for the cow to be bred. The rubbed off chalk indicates that she has been in "standing heat" since you last observed her and still would be a good bet to inseminate.

The oil-based chalk is relatively rain-resistant and unlikely to be rubbed off in brush. After seven to ten days, it will take on a flaky, crusted appearance as it dries. Some AI technicians choose to re-chalk cows when the chalk becomes weathered and dried, but no signs of riding have been apparent. Occasionally, a cow will lick off the chalk. Usually, the obvious lick marks on the hair of the tail-head indicate that she had not been ridden.

Tail-chalking and other heat detection aids are tools to aid good heat detection. However, these "tools" should not be expected to replace the trusted method of spending a half-hour in the morning and a half-hour in the evening each day carefully observing the cattle. See OSU Fact Sheet F-4154, "Heat Detection Aids for Beef and Dairy AI."

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Timing of Artificial Insemination:

Maximum fertility to artificial insemination occurs when cows are bred near the end of "standing heat." Ovulation occurs about 12 hours after the end of standing heat. The 12-hour lead time allows the sperm cells to go through a process known as capacitation by the time the egg is released. Fertility decreases slightly when cows are bred a few hours on either side of this target, and decreased markedly when breeding occurs more than 12 hours away from the end of "standing heat."

A guide that has proved to work well for timing AI is called the AM/PM rule (Table 2). At the end of the morning heat detection period, animals detected the prior evening are bred; at the end of the evening heat detection period, those observed that morning are bred. In some situations, AI must be employed once-a-day wherein all animals detected in the prior 24 hours are bred. Some studies show little decrease in fertility when this approach is used.

Cows First Showing Estrus	Should be Bred	Too late for Good Results		
In the morning	That evening	Next day		
In the evening	The next morning	After 3:00 p.m. next day		

Semen Handling:

The quality of frozen semen when it arrives at your farm or ranch is determined by the bull and organization that processed it. But once it arrives, it is up to you to take proper steps to ensure its viability.
Frozen bull semen can be stored indefinitely, if it is maintained constantly at very low temperatures. The critical temperature is approximately -112 degrees. Semen which is exposed to temperatures warmer than -112° F (even for a short time) and then returned to the storage tank may be damaged.

The extent of damage depends upon how long the semen is exposed to the elevated temperatures. Although it is easy to maintain frozen semen at a safe temperature, it is also easy to destroy it in a few moments of carelessness.

Tank Management:

The semen storage tank is a large vacuum-sealed metal bottle with an extremely efficient insulation system. Because of the vacuum bottle construction, the temperature can remain at -320° F (liquid nitrogen temperature) as long as at least two inches of liquid nitrogen is present. Technical advances in design and construction have produced storage tanks with a liquid nitrogen holding time of six to nine months.
Although semen storage tanks are well constructed, they still are susceptible to damage from mishandling. Semen tanks should be kept in clean, dry, and well ventilated areas. Avoid excessive movement of the tank. The inner chamber, which contains liquid nitrogen, is suspended from the outer shell by the neck tube. Any abnormal stress on the neck tube, caused by sudden jarring or an excessive swinging motion, can crack the tube. This results in vacuum loss from the outer chamber.

To increase holding time, keep the tank in a cool location away from direct sunlight. Avoiding drafts from furnaces and outside air also helps prevent excessive nitrogen evaporation. However, make sure there is sufficient ventilation in the room to prevent possible suffocation which can be caused by excessive nitrogen gas in the air you breathe.
Protect the tank from corrosion by keeping it elevated above concrete or wet floors. Use boards or pallets. Pick a location that is safe from children and vandals, but do not hide the tank; it must be placed where it can be seen daily and where it can be monitored routinely for nitrogen level.

Finally, always be watchful for a lid that is left off and for frost or sweat on the tank. Give particular attention to the neck and vacuum fitting. Frost indicates that the vacuum insulation has been lost, and liquid

nitrogen has been or is evaporating rapidly. If you suspect this has happened, use a wooden yardstick to measure the amount of liquid in the tank. If the tank contains liquid nitrogen, the semen must be transferred to a good tank immediately. Should the tank be empty of liquid nitrogen it is doubtful that the semen is viable; it should be evaluated before it is used.

Retrieving Semen:

In the typical farm semen tank, dangerous temperatures exist in the upper half of the neck tube. Exposure to these temperatures can occur when trying to locate a specific unit of semen or when transferring semen from tank to tank (Figure 1). Thermal injury to sperm is permanent and cannot be corrected by returning semen to liquid nitrogen.

In order to minimize thermal damage:

- Identify which canister contains the desired semen. A semen inventory which keeps track of the location of each bull prevents unnecessary searching.
- Remove the canister from its storage position to the middle of the tank. Raise the canister just high enough in the neck region to grasp the desired cane of semen. Keep the canister tops no higher than the frost line, or keep the tops of the canes no higher than two to three inches from the tank's top.
- Grasp the desired cane, and immediately lower the canister to the tank floor. Keep the cane as low in the tank as possible while removing the unit of semen. Use tweezers to remove the straw. If the straw is located in the upper goblet, bend back the top tab of the cane to a 45 degree angle. This will keep the straw from bending or breaking. The straw should be removed within 10 seconds from the time the canister is raised into position.
- Immediately after the unit of semen is immersed in water, return the cane to the canister by raising the canister up over the cane. Return the canister to its storage position.
- Any time it takes more than 8 to 10 seconds to locate a particular cane, the canister should be lowered back into the tank to cool completely. Never return a unit of semen to the tank once it has been removed from the cane.

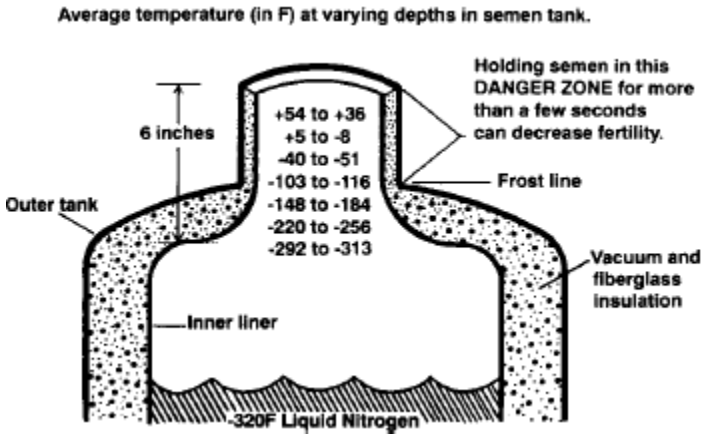

Figure 1 - Cross-section diagram of liquid nitrogen tank used to store semen.

Thawing Procedures:

The correct thawing recommendation for semen in straws is not the same for all AI organizations. However, almost all organizations now recommend warm-water thawing of straws for 10 to 60 seconds. For optimum results, follow the specific recommendations of the semen processor. Breeders may use semen from various AI organizations, but practice only one thawing procedure. The National Association of Animal Breeders has recommended that, when in doubt, 90 degrees to 95 degrees for a minimum of 40 seconds should be used

as a universal thawing recommendation.

A major concern with warm-water thaw is the danger of cold shock when the straw is mishandled after thawing. Cold shock is the permanent injury to sperm caused by a sudden decrease in semen temperature after thawing. It occurs when semen is thawed and then subjected to cold environmental temperatures before reaching the cow.
The severity of damage depends on rate and span of temperature drop. If precautions are taken to prevent cold shock, the advantage of warm thaw will be realized.

Here are some thawing tips:

- Always keep insemination equipment clean, dry and warm.
- Use a thermometer; do not guess at the temperature. Check the thermometer for accuracy at least every six months with a reference thermometer.
- Use an insulated water bath designed for thawing semen or a one-pint wide-mouth thermos which is deep enough to immerse the entire straw. Recently, electronic thawing devices which maintain water temperature accurately between 95 degrees and 98 degrees have been developed. These are convenient to use when breeding many cows at one time.
- Never thaw more than one unit of semen at a time. You breed your cows individually, so you should thaw units of semen individually.
- Gently shake the straw as it is taken from the tank to remove any liquid nitrogen that may be retained in the cotton plug end of the straw. Time the thaw with a watch to avoid guessing. When possible or practical, use thawing recommendations of the AI organization from which the semen was processed. When not possible, use NAAB's recommendation for 90 degrees to 95 degrees for a minimum of 40 seconds.

During Insemination:

One of the most frequent chances for semen damage is during transport to the cow. After thawing, the semen temperature must be maintained as close to 95 degrees as possible. Handling thawed semen and preparing the insemination rod should be done in a sheltered, heated area.

Proper steps for handling semen include:

1. While the semen is thawing, warm the insemination rod by rubbing it briskly with a paper towel. In cold weather, place the warm rod within clothing so it will be close to the body and maintain warmth.
2. After the semen is thawed for the required time, dry it thoroughly with a paper towel and protect it from rapid cooling.
3. Adjust the air space in the straw to assure that no semen is lost when the end of the straw is cut off. This can be done by slightly flicking the wrist while holding the straw at the crimp sealed end.
4. Transfer the straw to the rod and cut the tip of the crimp-sealed end of the straw squarely and through the air space. Only sharp scissors or a specially designed straw cutter should be used. Make sure to cut the straw "square" to achieve a good seal with the sheath.
5. Wrap the assembled insemination rod in a clean, dry paper towel, and tuck it within your clothing for transportation to the cow. Do not place the rod in your mouth or carry it uncovered in your hand.
6. Inseminate the cow within minutes after the semen has been thawed. The period of time between removing the semen from the tank and depositing the semen in the cow should not exceed 15 minutes.

Semen Transfer:

When transferring semen between tanks, follow these tips:

1. Have the tanks side by side and as close as possible. Fill the tanks with nitrogen before transfer, if possible.
2. Have the appropriate canister in each semen tank in the center position.

3. Transfer the canes quickly (within three to five seconds). Never touch the units of semen with bare fingers.

It is essential that frozen semen be handled and thawed carefully and properly in order to obtain anyone optimum results. It also is important to deal only with reputable, well-established AI organizations because their semen has been processed under standard, controlled conditions that are evaluated routinely.

Insemination Process

Although not part of the female genital tract, the rectum (terminal portion of the large intestine) is an important organ for you to become familiar with because your arm inside the cow will be working through this thin-walled tube. The rectum is 10 to 12 inches long and very stretchable. That is important because it is through the rectum that you will manipulate the cervix.

The anus serves as a valve between the rectum and the outside. It is made up of a circular (purse string) muscle located directly under the skin. It surrounds the very end of the rectum. Again, the anus is stretchable, hence, your hand and arm can easily slip into the rectum. Circular muscle contractions move along the rectal wall toward the outside. When strong, these contractions may block your hand from moving forward and make it difficult to manipulate the genital organs through the rectal wall.

Semen Placement:

The insemination process is quite straightforward. However, since relatively few sperm cells will be used, their placement is critical. The semen should be placed in the body of the uterus just in front of the cervix. You can recognize the proper site by the change in tissue consistency—from firm and hard in the cervix to soft and spongy in the uterus. To achieve the highest possible fertility rate, semen should be deposited at the very front end of the cervix. The internal (or front) end of the cervix is often called the anterior cervical os. To deposit semen at this location requires the use of a special device called Cassou pipette, or "AI gun." The recto-vaginal insemination process is used. The inseminator places his hand in the rectum and manipulates the reproductive tract so that the gun passes through the vagina, then it is manipulated through the cervical rings, and then held at the internal opening of the cervix for semen deposition. In adequately restrained cattle this will take 30 seconds to 2 minutes. At first, however, passing an insemination syringe might not be easy because you might encounter natural obstructions on your way to the target.

Beware of obstacles. The front end of the vagina forms a circular blind pouch where it joins the backward

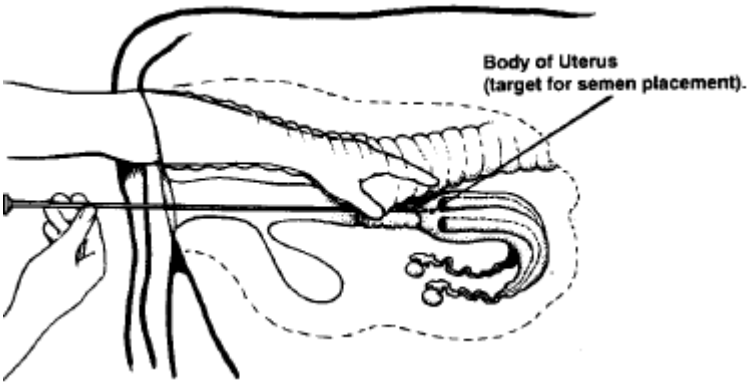

Figure 2 - Proper placement of insemination gun to deposit semen in the body of the uterus

projecting cervix. This blind pouch is usually from .5 to 1 inch deep, surrounding the entire dome-shaped back end of the cervix. You'll meet other obstacles once you're inside the cervical canal. Firm, finger-like projections arranged in three to four circular rings extend into the canal. These cause the passageway to be crooked and contain blind pockets, or dead ends. The circular blind pouch of the vagina and the winding cervical canal with its dead ends are the two major stumbling blocks for anyone learning how to artificially inseminate.

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Next to estrus detection, semen placement error (by the technician) is most likely to affect fertility. Correct semen placement is very difficult to confirm in the field. It is impossible to check pipette placement. The pipette position changes too easily. Postmortem tracts or examining culled cows inseminated with dye can be used to check semen placement after slaughter. Studies using dye deposition followed by slaughter have shown that up to 70 percent of the cows are inseminated incorrectly. The dye was placed in the vagina, posterior cervix, uterine horn, or bladder. The target for semen deposition is the anterior cervical os, a difficult site to find. Inexperienced inseminators often do not pass the pipette far enough, or they pass it too far into the uterine horns. Since the body of the uterus is only .5 to .75 inches in length, pipette passage 1 inch into the uterus results in most of the semen entering only one horn, effectively reducing conception. Semen deposition is often made too rapidly, and semen takes the avenue of least resistance. If one horn is not as open as the other, it does not receive enough semen.

Take your time while breeding a cow and depositing the semen. It only takes a few extra seconds to make sure semen is deposited correctly. The plunger should be depressed over a 5-second period, allowing the semen to flow slowly and evenly, divided between horns. In non-pregnant cows, walls of the uterus are soft and spongy. Inseminating syringes should never go beyond the front end of the cervix, because it is too easy to poke into or through the uterine wall. This could cause infection and perhaps even fatal peritonitis.

Sanitary technique:

Wash your hands. Inseminating cows is an invasion into the delicate uterine environment that is very conducive to growing bacteria. Bacteria on your hands could be transferred to your inseminating gun during the loading procedure. If carried into the uterus during insemination, these organisms could thrive and grow rapidly resulting in metritis and infertility.

Using technicians:

Professional technicians are more successful at insemination than inexperienced owners or managers. Inseminators should periodically attend AI courses in order to improve or correct techniques. Selection of a qualified inseminator is an important element in the success of the artificial insemination program. While the insemination process is simple to understand, it does require considerable manipulative skill. Semen-selling companies conduct three or four day training programs, which will provide individuals with sufficient skill to begin inseminating. However, recently trained individuals generally experience lower conception rates until they have inseminated a number of animals. Regular practice at inseminating is required to maintain high conception rates. In many localities, AI studs have trained inseminators who provide insemination service for a reasonable fee. Cattle operations where artificial insemination is routinely used often have a well-trained individual who may be available as a technician. Before producers make a decision whether to hire a trained technician or to train a member of the farm team, they should weigh the considerable cost of a reduced conception rate during the learning process against the fees paid to a trained technician.

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