ON-FARM SEMEN RECEIVING, STORAGE AND USE
FOR A SUCCESSFUL AI PROGRAM

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Introduction
North American sow farms are typically supplied with semen from an external boar stud and
sow farm personnel have little control over initial semen quality. However, even when high quality
semen departs the boar stud, thermal insults during transport (Flowers, 1996; Landsverk, 2000) or
during on-farm storage (Flowers, 2005; Young et al., 2005) have the potential to significantly
reduce sperm viability and reproductive success. The difficulty of maintaining a stable temperature
when semen is shipped via external courier (FedEx®, UPS™) has in part prompted many boar
studs and companies to set up a dedicated internal semen courier service. Lack of attention to boar
semen temperature management on-farm seems to be a remaining weak link in the semen transport
chain.

In many respects, boar sperm are amazingly resilient to chemical and physical insults.
However, compared to the sperm of other domestic ungulates (bull, ram, stallion), boar sperm are
more vulnerable to cooling induced membrane damage (White, 1993). Exposure of extended liquid
boar semen to temperatures near and below 12°C (≈ 54°F) typically induces membrane changes
that impair sperm function and lead to accelerated loss of sperm viability generally referred to as
“cold shock”. Storage of extended liquid boar semen around room temperature (22°C ≈ 72°F) can
also lead to accelerated loss of sperm viability because it does not sufficiently slow the active
metabolism of ejaculated sperm. Thus, the current standard boar semen storage temperature of 17°C
(≈ 63°F) represents a compromise between the need to cool sperm to reduce their metabolic rate
(waste product accumulation) and the need to keep sperm warm enough to avoid significant
membrane damage (loss of sperm function).

Semen Receiving
1. How frequently should we schedule semen delivery?

A perfect semen delivery program would provide the freshest possible semen to meet daily
changes in breeding demands at the sow farm without any over supply (zero semen wastage). In
reality, this is clearly not possible or at the least not practical and we must accept several limitations.
First, the sow farm’s weaning schedule largely dictates when semen will be required and fluctuation
of daily semen demands can only be estimated in advance, not known. Some semen over supply
will be unavoidable and is necessary given the alternative (question 3). Second, there is an
inevitable loss of sperm fertility and viability as storage age increases, especially after the third day
(72 hours). Establishment of a maximum shelf life or use-by date is useful for decision making at
the sow farm. Semen may need to be used by three to five days (72 to 120 hours) after time of
collection (0 hour) depending on the extender used and to some extent, the number of sperm per
dose. Third, preparation and delivery of semen doses, whether by internal or external courier, has
an associated cost that may be a significant factor. Depending on the above mentioned constraints
of the particular system, anything from five to two semen deliveries/week may be practical and can provide satisfactory reproductive results.

2. How should we handle semen deliveries at the sow farm?

Whether doses are delivered directly to the farm office or are placed into a remote drop-off cooler outside the farm by the courier, the goal is to keep their temperature stable and get them into the semen storage unit as quickly as possible. Before placing the doses in the semen storage unit, it is a good idea to check their temperature first, especially if the shipment was not transported in a temperature controlled cooler. An infrared thermometer (temperature gun) is useful to quickly estimate the surface temperature of the semen doses. Keep records of the arrival temperature, number of doses, specific genotype or line and use-by date of each delivery on a log sheet. Keep this log sheet on or near the semen storage unit to help minimize the number of times the door to the unit has to be opened. These records will be useful for managing the semen inventory which includes minimizing wastage by using the oldest semen first, discarding expired doses and ordering fresh semen. You can also include columns on the log sheet for twice daily checks of semen storage unit temperature, semen dose rotation and any sperm motility checks to ensure these tasks are not forgotten.

Semen should not arrive at temperatures outside of a 15 to 19°C (≈ 59 to 66°F) range. If deliveries arrive at inappropriate temperatures, inform the semen courier or boar stud through appropriate channels. They should be willing and able to change the departure temperature, transport cooler, shipping package, and (or) packing materials (temperature stabilizers) to resolve the issue. A digital temperature logging device can also be added to verify that the semen is not being exposed to significant temperature change during transport. If semen arrives at temperatures near or outside of a 12 to 22°C (≈ 54 to 72°F) range, sperm fertility, sperm viability and semen shelf-life are likely to be reduced. This situation could create an additional problem if the delivery is added directly to a semen storage unit already containing usable doses. Usable doses being held at 17°C could be exposed to significant temperature fluctuation as the storage unit attempts to warm or cool the added liquid mass. While it may be possible to partially warm or cool the doses at room temperature before transferring them to the storage unit, a more ideal option would be to have an empty semen storage unit available. In some cases, it may be justified to have two smaller storage units rather than one large storage unit on-farm (question 4).

3. How can we cope with a semen inventory shortage?

Even with careful attention to the number of weaned sows, cycling gilts, insemination doses used on a given day and projected insemination doses required for upcoming days there can be instances when the semen inventory on-farm will be insufficient to meet breeding demands. There may be time to put in a late increase of the semen order or to request an emergency semen delivery in some cases. Armed with the knowledge of a pending semen delivery it may be possible to simply delay insemination of the remaining females in estrus. However, in other cases, semen supply from the boar stud could be interrupted for an extended period. Most farms have a contingency plan in place and an alternate semen supply to deal with such emergencies. Sometimes the plan includes the use of semen from on-farm (heat check) boars to cover an external semen supply stoppage. It is important to remember however that sufficient boars, equipment and semen
preparation expertise must be present on-farm to make this a viable option. There are methods to more efficiently use the remaining semen supply in the event of an intermittent shortage. It may be prudent to administer fewer inseminations per estrus, use half of a dose for an insemination, or use expired semen doses as opposed to not breeding females in estrus at all. The focus of this strategy is to attempt to meet breeding and farrowing targets, which are more economically important than maintaining maximum litter size. The alternative and probably more costly strategy would be to use the remaining insemination doses on females anticipated to be the most fertile and skip-cycle some females less likely to produce satisfactory reproductive performance (gilts, late weaned sows, re-breeds).

**Semen Storage**

4. **What type of semen storage unit should we use and where should it be located?**

Only units specifically modified or designed for boar semen storage should be used. These semen storage units should have an internal fan to circulate air, multiple wire racks to arrange semen doses over, a precise thermostat (± 1°C) to control temperature and an external digital temperature display. Semen storage units with the ability to heat and cool are worth the expense. A cool only semen storage unit located in a barn, garage or shed area with no heating system will not be able to maintain 17°C when the ambient temperature drops below 63°F. Another reason that barn environments are not an ideal location is that exposure to moisture and corrosive gases can damage the semen storage unit and cause it to fail. Even when a heat and cool semen storage unit is used it is best to protect the unit from ambient temperature fluctuation and locate it in an HVAC controlled room such as the farm office. It is also wise to plug the semen storage unit into a dedicated outlet that you will not plug anything else into. Likewise, use of a surge protector and UPS battery back-up can provide an additional safeguard in the event of a spike or loss of electrical power.

Semen storage units are available in many different sizes (1.7, 2.5, 3.6, 4.0, 6.0 cubic feet) and corresponding approximate semen dose capacities (50, 75, 125, 150, 250 doses). On large sow farms and on sow farms with on-farm semen collection, it may be best to have two smaller semen storage units rather than one large one. One unit can be used for cooling semen and one for semen storage. In addition, having two semen storage units provides a back-up should one of the units malfunction. Regardless of the number of semen storage units, a thermometer should be added to each one to verify the internal temperature. Thermometers with so called ‘high low’ capabilities are useful since they give some indication of the temperature fluctuation inside the storage unit. Keep in mind however that the actual temperature changes of the semen doses will lag behind and may not be as extreme as the air temperature changes inside the storage unit. Water resists temperature change due to its high specific heat capacity and extended boar semen doses are more than 99% water. Placing a conventional thermometer in a water-filled (70 to 100 mL), screw-top semen bottle inside the storage unit provides an inexpensive way to verify the liquid temperature there. Digital thermometers are also available for around $25 that have high low recall capabilities and are connected via wire to a sensor that can be immersed in the water-filled bottle inside the storage unit. This type of setup adds the convenience of being able to check the current dose temperature and past temperature fluctuation without opening the storage unit door.

5. **What is worse, inappropriate storage temperature or repeated temperature fluctuation?**
As mentioned in the introduction, storage of extended boar semen at temperatures several degrees below or several degrees above 17°C leads to accelerated loss of sperm function and does not maximize semen shelf life (Pérez Marcos and Martín Rillo, 1995; Paulenz et al., 2000). However, storage of extended boar semen at a constant temperature other than 17°C within the 15 to 19°C (≈ 59 to 66°F) range is less damaging to sperm longevity than repeated temperature fluctuations of ± 2°C or more within this range. It has been suggested that for each ± 2 to 3°C (± 3.6 to 5.4°F) fluctuation up or down, sperm viability and shelf life may be decreased by as much as one day (Rozeboom, 2003). In addition, inappropriate semen storage temperature fluctuations have been associated with reduced sperm viability (Young et al., 2005) and reduced reproductive performance (Flowers, 2005).

The reason repeated cooling and warming cycles are so damaging to sperm function is largely due to the impact of temperature change on the sperm plasma membranes. Cooling of extended boar semen to 17°C for storage induces shifts in the organization of sperm plasma membrane components as the membranes become less fluid and more rigid and gel-like. As extended boar semen is warmed back to 37°C, some of the membrane component reorganization induced by cooling is not fully reversible. Thus, repeated temperature fluctuation likely causes cumulative damage to sperm structure and function. Boar sperm exhibit multiple phase transition temperatures around which shifts and lateral separation of plasma membrane components occurs. One phase transition temperature is not much above standard boar semen storage temperature, around 22°C (≈ 72°F, room temperature). Repeated warming of 17°C extended boar semen past 22°C followed by cooling back to 17°C should be particularly damaging. Collectively, this means that the temperature range over which fluctuation occurs and not just the magnitude of the temperature fluctuations that sperm are exposed to can influence the amount of membrane damage inflicted. In applied terms, once extended boar semen is cooled to 17°C, it should only be allowed to warm one time, during the insemination process.

6. What happens to sperm quality if we forget to rotate (re-suspend) the semen doses?

Gravity causes gradual sedimentation of non-motile sperm, motile sperm, cytoplasmic droplets, micro-organisms and other smaller particles in stored liquid semen. It has generally been assumed that this close contact and piling of dead and live sperm could create a toxic micro-environment within the extended semen dose where metabolic waste products build up and critical nutrients and buffering capacity becomes depleted. At present, there is somewhat contradictory data on the effect of semen rotation on boar sperm survival (Rodríguez-Gil and Rigau, 1995; Simmet et al., 1998). In addition, the increased buffering capacity of modern extenders (mid- and long-term extenders vs. BTS) and the increased surface area of current semen packages (bags and tubes vs. screw-top bottles) should in theory help minimize detrimental effects. At best, the rotation process could be beneficial to sperm survival in some situations; at worst, it could have no impact on sperm preservation. Regardless, gentle rotation of semen twice daily provides an opportunity to quickly examine and inventory the remaining doses and confirm that the semen storage unit is functioning properly. Regular rotation and re-suspension of the sperm just prior to insemination may also help prevent significant numbers of sperm from being left behind in the semen package as it is emptied during the insemination process. Therefore, it is wise to continue to consistently perform this quick and simple chore.
7. What effect does air, pressure and light have on liquid-stored sperm?

In theory, keeping air out of boar semen packages (bottles, tubes, bags) is desirable. Sperm in liquid storage will use the available dissolved oxygen supply and aerobic pathways to produce energy until lactate builds up and their internal pH falls. A downside of this type of efficient metabolism is that generation of reactive oxygen species can cause irreversible damage to the lipid components of sperm plasma membranes. Air (21% oxygen) that remains trapped in the slack space of boar semen packages could oxygenate the liquid and feed the aerobic metabolism of sperm. This may be why continuous agitation of stored liquid semen has actually reduced sperm viability in some cases. The gentle daily rotation of doses during storage however does not likely introduce much additional oxygen to solution provided rough handling and violent shaking of semen doses is avoided.

Another common concern is how the physical shock of inadvertently dropping a semen dose will affect sperm viability. Even though sperm are comprised of relatively fragile semi-permeable membranes and are subject to shrinking or swelling via osmosis due to solute concentration gradients, such a physical shock is not likely to damage them. In many ways water is an ideal “cushion” for sperm against shock. Water has been called nearly incompressible since it compresses very little even under a large amount of pressure. Thus, atmospheric pressure changes during air shipment of semen, for example, do not exert significant effects on sperm in liquid storage. Nonetheless, rough handling of liquid boar semen should still be avoided to reduce the risk of damaging sperm and the integrity of the semen dose package.

Sperm should also be protected from excessive light exposure, especially from the UV rays of the sun. Most semen dose packages are semi-transparent for convenience of use reasons but it is not difficult to limit their exposure to light.

Semen Usage
8. Should we warm semen prior to insemination?

Warming liquid stored semen prior to insemination is quite uncommon in North America. There is arguably one pro and several cons for such a treatment. When the entire insemination dose is warmed, a sample can readily be checked for adequate sperm motility (question 9). This represents a valuable last-minute opportunity to detect a semen quality problem and make a breeding decision. On the negative side, warming a number of insemination doses to 37° C (≈ 99° F) requires time and a water bath or dry incubator. In addition, excessive warming could actually damage the sperm and warmed doses must be kept warm and used for insemination. Warmed doses should definitely not be returned to the semen storage cooler for future use (questions 5 and 10). Finally, experimental evidence to suggest such pre-warming of semen improves reproductive results is lacking and the current consensus is that it is simply not necessary. It has also been recognized that the increasing temperature gradient of the sow’s vagina and cervix likely warms the semen gradually as it flows through the insemination catheter and is drawn into the uterine horns (Flowers, 1995).

9. Should we check sperm motility of semen doses prior to insemination?
Even though most boar studs hold a sample from each semen batch to check motility over the shelf-life of the semen, it is a good idea to check semen motility on-farm. If a significant handling mistake or storage malfunction occurred after the semen left the stud, a quick motility check prior to breeding may detect it. If only expired semen doses remain during an inventory shortage, a quick motility check on-farm could aid decision making. Granted, for this practice to be worthwhile, there has to be equipment (microscope, slides, cover-slips, warming device) present on-farm and an individual with the technical expertise to evaluate motility routinely available. A semen sample (1 to 3 mL) warmed at 37°C (≈ 99°F) for 15 minutes that yields sperm motility less than 60% is considered unacceptable. Consistent record keeping and good communication with the semen supplier are also mandatory.

10. Should we return leftover semen to the storage cooler once it has been removed?

The best answer to this predicament is to never remove more semen from the cooler than you know you will use in the breeding barn. It is better to make a final trip back to the semen storage cooler to get the last few doses required than to end up with several doses left in the transport cooler at the completion of breeding. These leftover doses should not be returned to the semen storage unit for future use, especially if significant warming has occurred (question 5). The general recommendation to never remove more doses from the semen storage unit than the insemination crew can use in one hour of breeding is logical. Using a small, 6-pack or 12-pack sized cooler is also a good idea since it limits the amount of doses that can be taken to the breeding barn at one time. Do not forget to include some 17°C gel packs in the semen transport cooler to insulate the doses against temperature change regardless of the season and barn temperature.

Summary

Careful attention to semen receiving, storage and use is warranted given the sensitivity of boar sperm to thermal insults and the potential impact of reduced semen quality on female reproductive performance. In addition, current surveys of industry practices indicate that exposure of boar semen to inappropriate temperature changes is quite common and has probably limited reproductive performance in certain cases. Consistent monitoring and record keeping of semen inventory, semen deliveries, semen rotation, semen storage unit temperatures and sperm motility checks are a necessity for a top-notch AI program. There is no legitimate excuse to ignore these important yet quick and simple tasks.

Take Home Message

The following checklist of twelve things to practice regularly and twelve mistakes to avoid should help your farm maintain proper semen receiving, storage and use techniques.

<table>
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<th>Do</th>
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<tbody>
<tr>
<td>✓ locate storage unit in an HVAC controlled room such as farm office</td>
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<td>✓ check temperature of semen deliveries and consistently keep records</td>
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<td>✓ communicate with stud if semen arrives at inappropriate temperature</td>
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<td>✓ place doses horizontally and spread them out for max air circulation</td>
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- clean storage unit interior regularly and check that door seals properly
- clean storage unit exterior regularly and check electrical power supply
- rotate doses gently and record high low temperature twice daily
- discard doses that exceed use-by date and monitor inventory
- use older semen doses first to avoid being stuck with expired doses
- check sperm motility of a warmed semen sample prior to insemination
- remove only as many doses that you are confident will be used
- transport doses to breeding in small cooler with 17° C gel packs

**Do Not**
- store semen in a regular refrigerator, regular cooler or at room temperature
- add doses or gel packs at temperatures near or outside of the 12 to 22° C (≈ 54 to 72° F) range directly to the storage unit if it contains usable doses at 17° C
- block air circulation around the back of the storage unit by stacking objects around it or by pushing it into a corner or against a wall
- store drinks, food, vaccines, etc. in the semen storage unit
- stack doses against the bottom or sides of the storage unit
- pile doses together or overload the storage unit
- leave the door to the storage unit opened for very long
- remove more doses than breeding can use within one hour
- forget to make sure the storage unit door is closed securely
- remove doses from the transport cooler until AI catheters are in place
- store doses in a tool caddy or in your pockets while working in the barns
- return doses transported to the breeding barn to the semen storage unit

**References**


Flowers, W.L. 1995. Answers to the 10 most commonly asked questions about A.I. Proceedings of the North Carolina Healthy Hogs Seminar, Greenville and Fayetteville, NC, USA.


