Ultrasound Guidelines Council
Field Technician Study Guide
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Chapter II – Ultrasound Basics
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Purpose = to briefly present some basic information about how ultrasound works, the evolution of ultrasound, and current applications in the livestock industry.

How Ultrasound Works
- Ultrasound technology is based on high frequency sound waves
  - Livestock applications use 2 – 20 MHz
  - Humans can only hear up to 20 kHz = 0.020 MHz
- Ultrasonic waves are generated by the transducer in short pulses
  - Piezoelectric crystals in the transducer convert electrical energy into ultrasound
  - Pulses of ultrasound directed into an animal are reflected and scattered by tissues and tissue interfaces.
  - Pulses that return to the transducer (called echoes) are displayed on the ultrasound console screen (and perhaps an external monitor) in a cross-sectional anatomical format
  - Characteristics of the image can be analyzed and conclusions drawn regarding the anatomy or health status.

Types of Ultrasound
- Biological applications require an ultrasound console, transducer, computer and frame grabber to capture and store images. Specialized computer software is required to interpret images.
  - Hence, the UGC definition of a system includes specification of all these items.
- A-mode = amplitude modulation = produces a one-dimensional ultrasonic image display.
  - Echoes appear as spikes on a display screen and the distance between spikes is related to distance within the animal
  - Useful only for measuring fat depth and muscle depth.
  - Used as a research tool in Animal Science.
- B-mode = brightness modulation = produces a two-dimensional image display
  - B-mode ultrasound integrates multiple A-mode signals
  - B-mode images consist of pixels of hundreds of shades of grey.
  - Developed in late 1960's and 1970's.
  - The time required for the echo to reflect back from the tissue to the transducer determines the location of the pixel on the screen.
  - Machines use a "soft tissue" average speed to calculate distances which may differ from actual speed depending on whether the sound wave was traveling through fat or lean.
  - The grey-scale allows differences in tissue texture to be seen.
    - Differences in tissue densities produce white pixels; consistent tissue densities give dark pixels.

- Real-time ultrasound is a version of B-mode that creates dynamic "live" images
  - Images change instantly as the transducer is moved.
  - Real-time images are produced by rapid electric switching from element to element in the sound field resulting from the ultrasound pulses.
  - Sound field, called a beam, is divided into multiple regions called the near field and far field which are important to beam focusing.
    - Gain settings on the ultrasound console adjust the brightness of the image field so the intensity will be similar at each depth of tissue.
      - Overall gain adjusts for the overall brightness of the image.
      - Near (far) gain adjusts the brightness in the near (far) field of the image
  - First developed for medical applications in the 1980's
  - Real-time ultrasound allows the measurement of muscle area.
  - Specialized computer software can be used to predict intramuscular fat percent from the grey scale and texture analysis of an image.

Real-time Ultrasound in the Livestock Industry

- The development of ultrasound technologies began in the late 1800's.
- A-mode ultrasound was used for diagnostic imaging of soft tissues as early as the 1950's.
- Wide-spread application of real-time ultrasound for genetic evaluation in beef cattle began in the 1990's.
- Frequency used depends on the application – i.e., the type of tissues
  - Lower frequencies gives greater tissue penetration, but lower image resolution
  - Higher frequencies give less tissue penetration, but higher image resolution
- Carcass evaluation uses longer transducer (17.2 cm) and longer wavelength (3.5 MHz)
- Reproductive evaluation uses a shorter transducer (5.6 cm) and shorter wavelength (5.0-7.5 MHz)

Real-time Ultrasound for Carcass Evaluation

- Real-time ultrasound allows the measurement of muscle area.
  - Earlier transducers were shorter (12.5 cm) and were unable to capture a large ribeye area in a single image
- Specialized computer software, first developed in the 1990's, is used to predict intramuscular fat percent from the grey scale of an image.
- Because transducers are rigid and straight they do not fit the shape of the animal well for some measurements.
  - Standoff pads were designed to act as acoustic couplers between the transducer and the animal.
- Part of what make real-time ultrasound so useful is that different tissues reflect ultrasound waves differently; however, some media inhibit ultrasound.
  - Changes in density of tissue cause reflection of the ultrasound waves at different velocities
    - Velocity formula
    - Velocity of ultrasound waves increases with increasing tissue density.
      - Velocity table
      - Tissue temperature also affects velocity.
        - Most real-time ultrasound scanners are calibrated at body temperature.

- Air reflects more than 99% of the ultrasound energy, while oils and gels reflect less than 1% .
  - Hence, coupling agents are used to prevent air getting between the transducer and the animal tissue and to provide an efficient medium for the ultrasound waves to travel
    - Vegetable oil is used for carcass evaluation
    - Ultrasonic gel is used for external reproductive evaluation
- Hair, dirt and debris on the animal trap air bubbles and prevent ultrasound waves from entering and returning from the animal.
  - Clipping the hair and brushing the animal at the ultrasound site promotes good contact between the transducer and the tissue (i.e., helps eliminate air) and helps the couplant work.