# SURVEY OF THE PRACTICE OF RADIOLOGY IN VETERINARY CLINICS IN THE STATE OF OKLAHOMA-1986

By

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SURVEY OF THE PRACTICE OF RADIOLOGY

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# PREFACE

This study is concerned with the application of radiology in the veterinary clinics within the State of Oklahoma. The purpose of the study was to collect and analysis data from the members of the Oklahoma Veterinary Medical Association, relative to the use of radiographic equipment, accessory equipment, radiographic techniques, radiographic film processing, radiation safety and assessment of selected charges. The data is to provide information for the purpose of discussion in formal and informal classes of Veterinary Radiology. Possible publication of this material may be warranted at a future date.

The author wishes to express his appreciation to the many people who have been involved with the development and completion of this study. Gratitude is expressed to the committee members, Dr. John Baird, Dr. Cecil Dugger, and Dr. Robert Bahr. A special thanks goes to Dr. Bahr, Section Chief of Radiology, Boren Veterinary Medical Teaching Hospital, for his patience and support through the past three years. His friendship has been very special to me.

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# CHAPTER I

## INTRODUCTION

"The ultimate goal in veterinary radiology is to produce radiographs of diagnostic quality" (Herrtage, 1978, p. 90).

The application of radiology is continually increasing in veterinary medicine. Advances in the understanding of the clinical manifestations of pathological processes and refinements in methods of treatment have created a need for improving accuracy in diagnosis (Gibbs, 1978). As the veterinary practitioner becomes more dependent on sophisticated diagnostic aids, the radiographic machine becomes more important.

According to Gibbs (1978), radiography is costly and time consuming, and a clear understanding of its applications and limitations is essential to obtain maximum benefit from its use. The following list indicates potential benefits/problems of radiography.

1. Radiography will only demonstrate disorders which produce structural or functional changes in organs or tissues.

2. An incorrectly positioned or moving patient or an under/over exposed radiograph might cause otherwise obvious pathological changes to be obscured.

3. Competent radiological interpretation must be based on sound knowledge of normal radiographic anatomy.

4. Any radiological sign must be related to some form of

anatomical or physiological change.

By applying this criteria, paying careful attention to the maintenance of high technical standards, and referring continually to the current literature, radiography can be used to make a positive contribution to the investigation of an ever increasing range of disorders.

## Need for the Study

The objectives for a radiology service were defined in a 1981 report by the American College of Veterinary Radiology (ACVR). The report, prepared for the American Veterinary Medical Association (AVMA), provided the Guidelines for Radiology Services in Veterinary Medicine. The objectives stated were as follows:

A. Produce radiographs of diagnostic quality.

B. Produce radiographs in a safe and efficient manner.

C. Produce radiographs in a cost effective manner.

D. Provide an accurate interpretation of the information available on a radiograph.

In reviewing radiographs presented to the Section of Radiology, Boren Veterinary Medical Teaching Hospital, for radiographic consultation, it became apparent that a substantial number of veterinary clinics in the State of Oklahoma were failing to meet the objectives defined in the above report. In an effort to evaluate the current state of the art of radiography in veterinary clinics in the state and to assimilate information for instructional presentations to the veterinary students, this report was conceived.

## Statement of the Problem

As assessment was needed on the practice of radiology in Oklahoma's veterinary clinics. The review was to establish the types of radiographic equipment and the radiographic techniques used in selected examinations. Reviews of the radiation safety practices and mean cost of referenced examinations will also be addressd.

## Purpose of the Study

The purpose of the study was to collect and analyze data from the members of the Oklahoma Veterinary Medical Association, relative to the use of radiographic equipment, accessory equipment, radiographic techniques, radiographic film processing, radiation safety, and assessment of selected charges. The data is to provide information for the purpose of discussion in formal and informal classes of veterinary radiology.

## Objectives of the Study

In order to accomplish the purpose, the following objectives were organized.

1. To identify the types of radiographic equipment.
2. To identify the types of radiographic films and screens.
3. To determine radiographic procedures performed.
4. To determine the mode of radiographic film processing.
5. To determine if radiation safety practices were used.
6. To assess the cost of selected radiographic procedures.

## Definition of Terms

The following definitions were taken from Morgan (1984).

Calcium Tungstate: A fluorescent salt used in the manufacture of x-ray intensifying screens.

Contrast: Relationship of the density of an image on the radiograph with densities of the surrounding images.

Density, Radiographic: The quantitative measure of the blackening of the photographic or radiographic image.

Dorsopalmar/AP: Describes entry of x-ray beam on the dorsum of the leg from the carpus and tarsus distally and exiting on the palmar surface of the leg

Film Badge: A photographic film used as a radiation monitor partly shielded to differentiate between types and qualities of radiation.

Film Speed: Characteristics of radiographic film that indicates how much radiation is required to produce a specified density on the film.

Grid: A thin plate consisting of alternating strips of radiopaque and radiolucent material which attenuate the scattered radiation.

Intensifying Screens: Used in contact with the x-ray emulusion in order to intensify or add to the photographic effect of the radiation falling upon it.

Kilovoltage peak (kVp): Determines the penetrating ability, or quality, or the x-ray beam.

Lateral View: Radiographic projection taken from the side of the animal.

Lead Apron: A lead rubber apron worn to protect personnel from

scattred radiation.

Lead Gloves: Lead rubber gloves worn to protect personnel from scattered radiation.

Milliamperage (mA): Term that describes the number of x-rays produced during an exposure--the flow of electrons across the x-ray tube.

Millamperage-Seconds (mAs): Exposure magnitude expressed as the product of milliamperage and time in seconds.

Photographic Effect: Ability of x-rays to be absorbed by a photographic emulsion and cause ionization that permits reduction of silver bromide to metallic silver.

Radiation Monitoring: A means of measuring the amount of exposure an occupational worker receives from ionizing radiation.

Radiographic Exposure: Radiation exposure for the express purpose of producing images on display systems, such as photosensitive emulsions, fluorescent screens, cathode ray tubes, etc.

Rare Earth Screens: Intensification screens that use rare earth phosphors.

Radiographic Film: Film designed for use in conjunction with intensifying screens particularly sensitive to ultraviolet and blue light.

Radiographic Units: An electro-mechanical system capable of producing a beam of x-ray.

Portable: A unit that can be hand carried.

Mobile: A unit that is on wheels and can be moved around the facility.

Fixed: A unit that is permanently fixed in one location.

Ventrodorsal View: Radiographic projection taken from the ventral (abdominal) side of the animal.

X-rays: Electromagnetic radiation of wavelength less than 100 Angstrom units produced by the interaction of an electron beam with a material such as a tungsten target in an x-ray tube.

## Scope and Limitation of Study

This study is limited to members of the Oklahma Veterinary Medical Association (OVMA) as listed in the 1986 roll of members as of April 1, 1986.

# CHAPTER II

## REVIEW OF THE LITERATURE

The purpose of this chapter is to present the reader with a review of the literature which describes theories and application of radiographic procedures. There are six primary areas of concern in establishing radiographic facilities. They are: equipment, films and screens, processing techniques, technique charts, radiation safety, and economics.

### Radiographic Equipment

The radiographic machine, generator, tube, tube stand, et cetera., should have a capacity which is adequate to produce consistent films of diagnostic quality on all types and sizes of patients normally treated in the hospital. Recommendations of the American Animal Hospital Association (AAHA) in the past placed 100 mA at 100 kVp as the minimum capacity for the machine. Within the last seven to ten years, most hospitals that have purchased new units obtained machines with the capacity of 200 to 300 mA at 125 kVp. These units, offered by a few companies which are seeking to directly serve the veterinary profession, have been quite satisfactory in their performance. Machines with capacities under the 100 mA at 100 kVp are less suitable for animal hospital use. With those units, most veterinarians were unable to consistently produce diagnostic films of larger patients. For obvious

reasons, portable x-ray machines with ten to 15 mA at 70-80 kVp capacities have even greater limitations. Portable machines do have value for use away from the hospital (AAHA, 1983).

Radiographic machines can be readily identified in three major categories: portable, mobile, or fixed units. Each unit has definite advantages and disadvantages. When the milliamperage is low, there usually must be an increase in the time of exposure in order to maintain radiographic density. The density is primarily controlled by the product of the milliamperage and the time in seconds. The product of these two variables is termed the milliamperage-seconds (mAs).

## Portable Machines

Approximate output is ten to 30 mA and 70-90 kVp. The principle limiting factor is the low mA which necessitates longer exposure times and thus predisposes to blurring as a result of movement. These units can be satisfactory for examination of the canine skeletal system and the lower limbs of larger animals. The limitations of the portable machine becomes more apparent when attempting radiography of the abdomen and, in particular, the chest. Blurring caused by respiratory movement is, of course, a major problem when radiographing the chest (Douglas, 1978).

## Mobile Machines

The maximum output of the majority of these machines is likely to be 40-60 mA and 90 kVp. There are a few machines that have much higher output (300 mA and 125 kVp). In general, these machines are suitable

for small animal work and the increased output enables most radiographic examinations to be attempted. They can be rather cumbersome to maneuver when working around large animals, but the higher output would permit radiography of the upper limbs, head, and neck (Douglas, 1978).

Fixed Machines

The output of these machines may reach as high as 1500 mA and 150 kVp. Smaller units with outputs of 300-500 mA and 125 kVp are now finding their way into some veterinary practices as secondhand machines. Providing that the problem of installation (adequate space, safety protection, suitable electrical supplies, etc.) can be overcome, such machines would permit practically all small and large animal examinations to be attempted (Douglas, 1978).

## Radiographic Films and Screens

X-ray film is exposed primarily by the visible light which is produced when an x-ray photon strikes the intensifying crystals on the screen. The amount of light emitted by the screen is proportional to the amount of radiation absorbed by the intensifying screens. The more light a screen produces, the less x-ray exposure is needed to expose the radiographic film (Pharr, 1979).

Because of the increased use of radiography in human medicine and an increase in the concerns of exposure to the general population, there has been extensive research on the production of screens which would be more light efficient. Rare-earth screens were the result of

this research. For decades almost all conventional intensifying screens were made with the phosophor: calcium tungstate.

Rare-earth screens made from lanthanum oxybromide emit blue light, as do the calcium tungstate screens. This allows for the use of the same radiographic film and allows a significant reduction in the amount of radiation necessary to produce a radiographic image. When compared against high-speed calcium tungstate intensifying screens, the lanthanum oxybromide intensifying screens allow a reduction of 75 percent in exposure. This reduction is normally accounted for in the reduction of the time of exposure, resulting in radiographs with less patient motion. The reduction in exposure also reduces the amount of radiation received by the patient and, therefore, the amount of radiation exposure to health care personnel.

## Radiographic Processing

Proper darkroom techniques are essential to the production of diagnostic quality radiographs and generally enhance the capabilities of the radiology facility. Poor darkroom design, technique, and maintenance are probably the major cause of poor radiographic quality in private practice. Thus, the private veterinary practitioner is encouraged to understand and practice good darkroom technique (American College of Veterinary Radiology (ACVR), 1981).

Most veterinarians process radiographs by hand, although many practitioners are purchasing automatic processors. This latter group appears to be increasing rapidly. The major advantage of automatic processors are the consistency and speed of film processing. The major advantages of automatic processors are the consistency and speed of

film processing. The major disadvantages is the cost of the unit which is often partially offset by an increasing radiographic case load due to the increased convenience of processing. Although automatic processors are a definite advantage, one should attempt a cost analysis and try to project the need for, or benefits of, such a unit prior to purchase (ACVR, 1981).

The general principles of good darkroom technique apply whether manual or automatic processing is employed. The darkroom should be kept clean to avoid radiographic artifacts. Proper darkness must be maintained; this includes elimination of light leaks from around doors and proper safe-light wattage and filters. In order to maintain radiographic quality, consistency in film processing must be adhered to. The principles of a time-temperature relationship must be observed and proper replenishment maintained (ACVR, 1981).

## Radiographic Technique Chart

A technique chart is a table with pre-determined x-ray machine settings that enables the radiographer to select the correct machine settings based on the thickness of tissue and the anatomical portion of the body to be radiographed. Use of these machine settings will regularly produce a diagnostic radiograph. Technique charts become of value only when the radiographer has developed confidence in them. The technique chart prevents unnecessary waste of time and film due to the use of inappropriate exposure factors. Use of a technique chart does away with the necessity of sight developing. It is often believed that a combination of mA, time and kVp settings that produces a satisfactory

radiograph when used with one machine will also produce acceptable radiographs with another machine. This is not true as part of the problem lies with basic inherent differences in the x-ray machines while different types of accessory radiographic equipment and procedures also contribute greatly to production of a different quality of radiograph. Factors which may contribute to these differences are:

1. Speed and age of the intensifying screen
2. Speed of the radiographic film
3. Focal-film distance
4. Amount of beam filtration
5. Temperature and time of processing
6. The type of grid (if one is used)
7. Inherent differences in the settings of the x-ray machine

It is because of these factors that a technique chart must be developed for each particular x-ray machine and processing facility (Morgan, 1984).

## Radiological Safety

X-rays are a form of radiant energy of extremely short wavelength produced when a fast moving stream of electrons collide with a tungsten target. The primary radiation is emitted in all directions although the design of the x-ray tube is such that the intensity is directed toward the tube port. The x-ray beam thus produced and emerging from the port is referenced as the primary beam. It is the primary beam that is used in the production of the radiographic image. This image is formed by the differential absorption of the x-ray beam by the various tissue compositions and organs of the animal, resulting in the

various densities produced on the film (Lee, 1978).

It was noted that there were two major sources of exposure to health care personnel involved in the radiographic examination:

1. The primary radiation coming from the radiographic tube.
2. The secondary or scattered radiation produced by the interaction of the primary beam and the animal.

The obligation of the owner/operator of radiographic equipment is to safeguard the health of their employees and the general public from possible harmful effects of radiation. The dangers to the animal are relatively small, although the possible effects on breeding animals and pregnant females should always be considered when radiographic examinations are performed (Lee, 1978).

Areas that should be considered for protection from unnecessary radiation exposure include the following (NCRP, #36):

1. The tube housing should be so designed that there is a minimum amount of radiation coming from other than the port.
2. The primary beam should be filtered with 2mm of aluminum to remove the long wavelength radiation from the beam.
3. The primary beam should be so restricted to the area of clinical interest through the use of cones, diaphrams, or collimators.
4. All personnel associated with the radiographic procedures should be adequately protected with lead aprons and gloves.
5. The animal should be passively restrained, if at all possible, so that personnel are not required to immobilize the patient.

## Economics

The break-even concept is the most accurate cost accounting

technique for establishing fees for radiographic examinations. In this technique the fixed costs and variable cost are determined. When the number of radiographic examinations are known, a fee for each examination can be calculated that will pay for all of the cost associated with that radiographic examination (Ticer, 1984).

Fixed costs are generally considered to be the cost of the facilities and of the radiographic equipment. The building is assessed in accordance with the number of square feet that produce income. Equipment is generally classified as material expected to last over 12 months and cost more than $100.00. The annual cost of the facility and equipment should include: maintenance, taxes, and insurance expenses.

Variable cost would include the salaries associated with personnel employed by the facility. In addition to salary, cost of expendable items, utilities, office supplies, bank charges, accountant and lawyer fees, and the cost of continuing education and licenses may be included.

## Summary

The review of literature presented background information on six primary areas of concern in establishing a radiographic facility. They included equipment, films and screens, processing techniques, technique charts, radiation safety, and economics.

The application of radiological techniques in veterinary medicine has continued to increase in the past three decades. This growth is associated with the sophistication of diagnostic tools for the treatment and interpretation of clinical signs and symptoms in both the human and

animal population. In order for the veterinary practitioner to take advantage of the advances which are changing daily, it is important to recognize the relationship of many parameters which influence the production of radiographs of diagnostic quality.

# CHAPTER III

## METHOD OF STUDY

The purpose of this chapter is to describe the methods and procedures used in conducting the study. The main purpose was to survey the types of radiographic equipment and the types of radiographic procedures used in veterinary clinics in the state of Oklahoma. Thus, the purpose provided guidance for the design of the investigation.

As was stated in the review of literature, there are many areas involved in developing an effective radiographic facility. The primary areas which were used for criteria in the review of the literature are equipment, films and screens, processing techniques, technique charts, radiation safety, and economics.

### Study Population

A review of traditional sources of literature indicated that there has not been similar research in the evaluation of radiographic facilities in veterinary clinics. Review of the quality of radiographs submitted to the Section of Radiology, Boren Veterinary Medical Teaching Hospital, for radiographic consultation indicated that there was a need to assess the use of radiology in veterinary clinics in the State of Oklahoma. Discussion with senior veterinary students who had participated in the College of Veterinary Medicine preceptor program

indicated that there was a lack of uniformity in the use of radiological techniques. With these two concerns in mind, it was decided to conduct a state wide survey of Oklahoma Veterinary Medical Association (OVMA) member veterinary clinics.

## Development of the Instrument

In developing the questionnaire, the writer set up a form which would identify six primary areas. They are:

1. Identification of radiographic equipment
2. Identification of films and screens
3. Identify techniques for selected examinations
4. Identify the mode of film processing
5. Survey the use of radiation safety
6. Assess the charges for selected examinations

Eighty-eight questions were developed in the closed questionnaire format. Responses called for a simple "yes" or "no" answer, a short response, or item check.

## Collection of Data

The 1986 membership list of the Oklahoma Veterinary Medical Association (OVMA) was obtained from the executive office of the OVMA. The veterinarian's name and the address of the clinic was obtained for use in mailing the survey. There were 692 members identified on the membership list. It was decided to exclude members who were known to be involved in academics, administration, or who were no longer actively participating in a veterinary clinic.

The survey questionnaires were with a cover letter by the Dean,

College of Veterinary Medicine and the director of Radiology, Boren Veterinary Medical Teaching Hospital, was mailed on April 15, 1986. A return date of no later than August 15, 1986 was requested.

## Analysis of Data

After the completed questionnaires were received, the data was inputed into the radiology IBM PC/XT computer, using the program "DATA EASE." Descriptive statistics including means, frequencies, and percentages were used in analyzing the data and describing the results. Reference to the veterinary clinics can be made by placing the last four digits of the telephone number first and then adding the first three numbers. It was this seven digit number that was recorded on some data sheets.

# CHAPTER IV

# RESULTS

The purpose of this study was to collect and analyze data on the practice of radiology in veterinary clinics in the State of Oklahoma. The study was restricted to the members of the Oklahoma Veterinary Medical Association as of April 1, 1986. Members of the association, who could be identified as members of the academic community, administrators, or who were no longer actively practicing veterinary medicine were excluded from the survey. There was a total of 646 questionnaires mailed on April 15, 1986. Forty-one and three tenths percent or 267 questionnaires, were returned by the end of the four month period.

## Analysis of Data

The analysis of data is represented under six headings: (1) Types of radiographic equipment; (2) Types of radiographic films and screens; (3) Radiographic techniques of selected examinations; (4) Modes of radiographic film processing; (5) Radiation safety practices; (6) Cost of selected radiographic examinations.

### Types of Radiographic Equipment

Two hundred and six radiographic units were identified in the survey. These units were classified as to portable, mobile, or fixed. Units were further identified as to manufacturer, year purchased,

whether the purchase was for a new unit or used unit and if the purchase was prior to or after January 1, 1980. Minimum, maximum, and mean values for milliamperage (mA), kilovoltage (kVp), and cost was established. Survey data collected is presented in Table I through Table XVI.

Portable units represented 35 percent or 73 units and identified ten manufacturers. Two units were not identified as to the manufacturer. For new units purchased prior to 1980 the mean mA was 18, mean kVp was 77 and the mean cost was $1699.16. For new units purchased after January 1, 1980 the mean mA was 21, mean kVp was 83 and the mean cost was $3075.71. Units purchased used prior to 1980 the mean mA was 37, the mean kVp was 85 and the mean cost was $490.71. Units purchased used after January 1, 1980 , the mean mA was 34, the mean kVp was 83, and the mean cost was $1287.50. Data on seven units did not provide information relative to new or used, cost or year purchased. However, the mean mA was 23 and the mean kVp was 74.

Mobile units represented 22 percent or 45 units and identified 12 manufacturers. One unit was not identified as to its manufacturer. Only one new unit had been purchased prior to January 1, 1980, the mean mA was 25 and the kVp was 95. The cost of this unit was not provided. Two new units were purchased after January 1, 1980, the mean mA was 30, the mean kVp was 93 and the mean cost was $3065.00. For used units purchased prior to 1980 the mean mA was 59, the mean kVp was 103, and the mean cost was $1246.15. The used units purchased after January 1, 1980 had a mean mA of 78, a mean kVp of 96 and a mean cost of $2039.28. Five units could not be classified as to date of purchase or as to whether the units were new or used. The mean mA of the units was 94,

the mean kVp was 101, and the mean cost was $1350.00.

Fixed units accounted for 34 percent or 71 units and represented 15 manufacturers. The mean cost of a new unit purchased prior to 1980 was $5591.50, with the mean mA being 160 and the mean kVp at 110. For a new unit purchased after January 1, 1980 the mean cost was $9469.09 and the mean mA was 300, with a mean kVp of 120. Used units purchased before 1980 had a mean mA of 132 and a mean kVp of 98. The mean cost was $2121.73. Used units purchased after January 1, 1980 had a mean mA of 173, mean kVp of 100 and a mean cost of $2642.33. Three units could not be referenced as to either date purchased, cost, or if the unit was purchased new or used. The mean mA of these three were 60 and the mean kVp was 90.

Seventeen radiographic units could not be classified as to portable, mobile, or fixed. Six manufacturers were identified. Eleven units had no designation as to manufacturer.

## Types of Radiographic Film and Screens

The information on radiographic film, radiographic intensifying screens and the relative speed of the screens were provided in Table XVII through Table XX. Radiographic films were identified as to manufacturer, facilities counted and percentages. Twelve manufacturers were noted, with three of the companies representing 78 percent of the film used. 3-M Corporation represented 39 percent or 47 facilities, Dupont had 20 percent or 24 facilities, and Kodak had 29 percent or 23 facilities. The remaining nine companies represented 22 percent or 27 facilities.

Radiographic screens were referenced as to information on manufacturers, facilities counted, and percentage. Eleven companies were identified on the survey of screens. The leading two companies were Dupont with 47 percent or 54 facilities and Kodak with 33 percent or 38 facilities. Nine other manufacturers represented 20 percent or 24 veterinary clinics.

The radiographic film/screen survey portion of the questionnaire, also asked for the speed of the intensifying screen. One hundred and twenty-six responses indicated that 33 percent or 40 clinics were using the new rare earth type screens. While 46 percent or 57 facilities were using hi plus and 21 percent or 26 facilities were using the old par speed screens.

## Radiographic Techniques of Selected Examinations

Techniques for examination of the small animal thorax, the small animal pelvis and the large animal carpus was requested. The information was classified as to the type of equipment used; portable, mobile, or fixed. The data also represents the minimum, maximum, and mean of the mA, time, kVp, and distances. The use of a grid was also considered. The millamperage (mAs) was calculated from the mean mA and the mean time values. Data on techniques is found in Table XXI through Table XXIII.

Radiographic techniques for the small animal thorax measuring 15 centimeters (cm) in the lateral projection indicates that the average technique for a portable was 8 mAs, 68 kVp, 33 inch target film distance (TFD), and no grid. The technique for the mobile unit was 16

mAs, 62 kVp, 31 inch TFD, and no grid. For the fixed unit the average settings were 20 mAs, 69 kVp, 36 inch TFD, and a grid was used 58 percent of the time.

The radiographic examination of a 12 cm small animal pelvis provided data that the mean technique for the portable unit was 9 mAs, 68 kVp, 32 inch TFD, and no grid. The mobile units average technique was 16 mAs, 61 kVp, 32 inch TFD, and no grid. For the fixed unit the average mAs was 22, the kVp 67, TFD was 36 inch, and 26 out of 38 responses indicated they were using a grid.

The technical factors for radiography of a 10 cm large animal carpus gave the following information. A grid was used on one out of 19 responses on the portable, not at all on the mobile and one out of five on the fixed unit. For a portable unit, the mean mAs was nine, the mean kVp was 70, and the mean TFD was 30 inches. The values for exposure on the mobile unit was a mean mAs of 12, the mean kVp was 69 and the TFD was 32 inches. Five responses implied that they were using a fixed unit for radiography of the large animal carpus. The data for this unit was a mean mAs of 35, mean kVp of 63, and mean TFD of 36 inches.

## Modes of Radiographic Film Processing

This part of the survey questionnaire addressed the question of how radiographic film processing was being accomplished in the veterinary clinics. Eighty five percent or 147 facilities indicated that they were manually processing their radiographs at the clinic. The minimum, maximum, and mean values for temperature and time of

processing in both the developer and fixer is provided in Table XXV.

Nine new and three used automatic processors were reported. The average cost of the new units were $3500.00 One used unit had a price listed and it was for $500.00. Ten companies were identified on the automatic processor list. Complete data is included in Table XXVI. Eleven veterinary clinics indicated on their surveys that they were processing the radiographs away from the office. This is usually done at another clinic, either veterinary or human.

## Radiation Safety Practices

The survey of radiation safety practices in the clinics was to address the effective control of radiation hazards. Question one dealt with whether personal monitoring was being provided to the radiation worker. Ninety-eight percent or 103 facilities were providing either film badges--80 responses, or thermoluminescence dosimetry (TLD)--23 responses. Two percent of the responses indicated they did not have personnel monitoring available. Eighty-five of the respondents indicated that they badge each individual who might be exposed to ionizing radiation, this comprised 94 percent, where four percent or five responses indicated that they were utilizing a group badge to monitor personnel. The change period for the monitoring systems, revealed 52 percent or 49 clinics were changing on a monthly basis. Forty-six or 44 clinics were changing on a weekly schedule, and two facilities were changing on a quarterly basis.

The second question asked if lead aprons and lead gloves were available and if they were being used. Ninety-eight percent or 169 facilities indicated "yes", with two percent or four clinics responding

that they did not have protective equipment. The last question was to determine if the veterinary clinic had been inspected by the Radiation Control Division of the Oklahoma Department of Health. Seventy-eight percent, or 124 clinics, indicated "yes" and 22 percent or 35 clinics indicated "no". Data is contained in Table XXVII.

Cost of Selected Radiographic Examinations

The cost assessment was based against the examinations referenced in the radiographic technique portion of the questionnaire. These examinations were for two views of the small animal thorax, two views of the small animal pelvis, and two views of the large animal carpus. Data collected was evaluated against the minimum, maximum, and mean cost in each examination area. Data referenced is also provided in Table XXVIII. The cost range for two views of the small animal thorax was $12.50 to $67.50 with a mean of $32.50. The assessment of the small animal pelvis provided the same range and mean as did the small animal thorax. The cost for the large animal carpus ranged from $12.50 to $50.00 with the mean being $29.37.

The final analysis of data revealed 57 respondents were not providing radiology services. Twenty-four duplicate records were identified. Sixteen clinics had two radiographic systems, two facilities had three units and one clinic had four radiographic machines. Referenced data are contained in Table XXIX.

# CHAPTER V

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to collect and analyze data on the use of radiology in veterinary clinics in the State of Oklahoma. A questionnaire was developed and mailed to the membership of the Oklahoma Veterinary Medical Association. A total 646 questionnaires were mailed on April 15, 1986 with a requested return of August, 15, 1986. A return rate of 41.33 percent provided 267 responses from which to develop an assessment of the use of radiology in veterinary clinics in the State of Oklahoma.

### Conclusions and Recommendations

The findings of this study can be most effectively reported by responding to the questions formed by the objectives posed in Chapter I. The answers to the following survey questions are based on an analysis of the information contained in the preceding chapter.

#### Survey Question One-Radiographic Equipment

Data on radiographic equipment identified 206 units and 23 manufacturers. Portable units purchased new after January 1, 1980 had increased in mean price by 44.7 percent, and the mean mA had increased by 14.3 percent, while the mean kVp came up only 6.3 percent. Used

portable units purchased after January 1, 1980 increased in mean price by 72 percent, while the mean mA had decreased by 9.2 percent and the mean kVp by 2.4 percent.

Mobile units had only one unit purchased new prior to 1980, no price was available on this unit. Two units purchased new after January 1, 1980 average $3065.00 this data does not allow for a reference between the systems on price. There was an increase in the mean mA of 16.7 percent and a decrease in the mean kVp by 2.1 percent. Used mobile units rose in mean price by 39 percent for machines purchased after January 1, 1980. The mean mA increased by 24.4 percent and mean kVp decreased 6.8 percent.

There was an increase in the mean price for new fixed units purchased after January 1, 1980 by 61 percent. However the mean mA of these units also increased by 45 percent and the mean kVp by 8.3 percent. Used fixed units increased by 19.7 percent for units purchased after January 1, 1980, while the mean mA increased by 33.7 percent, and the mean kVp by 2.0 percent.

It might be assumed that if we would conduct a follow-up of this survey for a number of years that there would be little change in the types of equipment available to the practicing veterinarian. The only major changes projected would be a continuing increase in the mean prices for all styles of radiographic equipment, with only a modest increase in the mean mA and mean kVp.

Survey Question Two-Radiographic Film/Screens

Radiographic film information identified 12 companies providing

film to the veterinary community. Three companies accounted for 78 percent of the film usage. These companies are also highly visible national corporations and would also represent the majority of human radiography usage.

Radiographic screens revealed 11 manufacturers with Dupont and Kodak holding 80 percent of the market. An assessment of the relative speed of the screens indicated there were 21.39 percent plus still using the old par speed screens. Forty-one and two tenths percent were using the new rare earth screens. It is hoped that within a short period of time there could be a discontinuance of the par speed screens as more used rare earth screens are released on the market.

Survey Question Three-Radiographic Techniques

The assessment of the radiographic techniques is difficult due to the fact that many assumptions relative to the combined factors of film, screens, speeds, technical settings, processing, and machine output are not standardized. When reviewing the relationship between the portable and mobile techniques for the small animal thorax the mA is approximately doubled on the mobile and the kVp on the portable system is increased by six, this would provide for radiographs that would be approximately half the density on the portable as on the mobile. This may be corrected when it is noted that twice as many hi-plus screens were identified in the portable tally as was identified on the mobile. The fixed unit increased in the mean mAs, the mean kVp, and the mean TFD. These parameter settings may be offset by the fact

that 57.5 percent of the respondents indicated the use of a grid.

The review of the techniques for the small animal pelvis show a mean technique equal to what was used on the small animal thorax. This provides a close correlation to what would be expected when changing from a primarily air filled cavity to a bony structure. The exposure parameters for the large animal carpus must be assumed to be from the portable and mobile units. It is unlikely that the veterinary practices were doing radiography on the equine patient with a fixed unit. However, there was five responses in this area. Techniques for radiography of the carpus using either the portable or the mobile units were very close to being equal when the mean radiographic effect is considered.

Any further review of techniques for radiography of the veterinary patient should be made at the clinics. This would allow for greater accuracy when examining all of the factors which contribute to the total radiographic image.

Survey Question Four-Radiographic Processing

The majority (86.4 percent) of veterinary clinics were manually processing the radiographs. The analysis of the mean data relative to manual processing provided a true linear response of the time--temperature relationship. However, when reviewing the individual responses from the survey some extremes to acceptable processing techniques were noted. Twelve automatic processors were identified in the survey. Half of which were purchased within the last five years, and only one of the remaining was purchased prior to 1980. There were

few facilities who had elected to forego the expense or trouble of manual processing and processed their radiographs outside the clinic. It might be projected that further studies would show an increase in the number of automatic processors as more used units are made available and prices are reduced.

Survey Question Five-Radiation Safety

The first area of radiation safety was to address personnel monitoring. One hundred and three responses out of 105 indicated they were providing some form of personnel monitoring to the occupationally exposed worker. The use of film badges was the most acceptable means of monitoring. This is probably related to the fact that the college uses this form. The Oklahoma Department of Health, Radiation Protection Division usually recommends the use of thermoluminescence dosimetry, because of its longer useful life, which does not require as frequent a period of change as does the film badge. The response on the availability and usage of the lead aprons and gloves, indicated that protective equipment was being provided 97.7 percent of the time. A field study on the integrity of protective equipment used in the veterinary clinics might prove to be of interest. The portion of the survey questioning inspection by the state provided 159 responses, of which 78 percent or 124 indicated that they had been visited by one of the inspectors. Information from the Oklahoma Department of Health, showed that by the end of 1986, 145 facilities had been inspected.

Survey Question Six-Assessment of Cost

The assessment of the cost of selected radiographic examinations, indicates that the mean cost for two views of the thorax or the pelvis of a small animal patient was $32.50. The differences in the minimum and maximum for these examinations may possibly be attributed to the cost of anesthesia being included. The cost for radiography of the large animal carpus had a mean price of $29.37. The spread in the range here may be associated with cost for traveling to the clients to provide radiographic services.

It is recommended that additional studies regarding the use of radiology in veterinary clinics be undertaken. The information derived has provided data relative to the types of radiographic units, the types of radiographic film/screens, radiographic techniques for selected examinations, modes of radiographic film processing, a review of the use of radiation safety and an assessment of the mean cost of selected radiographic examinations. Further studies should incorporate visits to the facilities for the purpose of direct interview and recording additional information. Photographic documentation of radiographic units and of the radiology area would be strongly suggested.

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# APPENDIXES

# APPENDIX A

TABLE I THROUGH TABLE XXIX

TABLE I

RADIOGRAPHIC UNITS

| MANUFACTURES | PORTABLE | MOBILE | FIXED | NOT IDENTIFIED |
|---|---|---|---|---|
| BENNETT | 0 | 0 | 5 | 0 |
| BOWIE | 13 | 0 | 0 | 0 |
| CGR | 0 | 1 | 0 | 0 |
| CONTINENTAL | 0 | 2 | 2 | 2 |
| DIAGNOSTIC X-RAY | 1 | 0 | 0 | 0 |
| EUREKA | 0 | 0 | 1 | 0 |
| FISHER | 5 | 6 | 8 | 1 |
| GENERAL ELECTRIC | 3 | 6 | 13 | 1 |
| KELLY-KOETT | 0 | 1 | 0 | 0 |
| KRAMEX | 16 | 0 | 0 | 0 |
| MACHLETT LABS | 0 | 0 | 1 | 0 |
| MATTERN | 0 | 0 | 1 | 0 |
| MIN X RAY | 12 | 0 | 1 | 0 |
| PHILLIPS | 0 | 1 | 0 | 0 |
| PICKER | 4 | 7 | 3 | 0 |
| PROFEXRAY | 11 | 8 | 8 | 1 |
| SEREND | 4 | 0 | 0 | 0 |
| STANDARD | 0 | 1 | 2 | 0 |
| TOSHIBA | 0 | 1 | 0 | 1 |
| TRANSWORLD | 0 | 0 | 1 | 0 |
| UNIVERSAL | 2 | 8 | 13 | 0 |
| WRAPPLER | 0 | 0 | 1 | 0 |
| WESTINGHOUSE | 0 | 2 | 11 | 0 |
| UNKNOWN | 2 | 1 | 0 | 0 |
| NOT DEFINED | 0 | 0 | 0 | 11 |
| TOTAL | 73 | 45 | 71 | 17 |
| TOTAL UNITS | | **206** | | |

TABLE II

PORTABLE UNITS PURCHASED NEW PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| BOWIE | | 20 | 80 | | 78 |
| BOWIE | | 10 | 70 | | 76 |
| BOWIE | | 15 | 80 | 2,395.00 | 78 |
| FISCHER | FP-100 | 10 | 90 | | 77 |
| FISCHER | FP-200 | 20 | 90 | 2,000.00 | 76 |
| KRAMEX | PX20N | 20 | 72 | | 78 |
| MIN X RAY | 100 | 15 | 63 | 1,200.00 | 79 |
| MIN X RAY | | 15 | 63 | | 65 |
| MIN X RAY | | 15 | 63 | | |
| MIN X RAY | 100 | 15 | 63 | 1,000.00 | 74 |
| MIN X RAY | 300 | 30 | 100 | 3,000.00 | 76 |
| SEREND | | 15 | 63 | 600.00 | 70 |
| UNIVERSAL | | 30 | 100 | | 56 |
| minimum | | 10 | 63 | 600.00 | |
| maximum | | 30 | 100 | 3,000.00 | |
| mean | | 18 | 77 | 1,699.16 | |

TABLE III

PORTABLE UNITS PURCHASED NEW AFTER JANUARY 1, 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| BOWIE | | 20 | 80 | 2,500.00 | 80 |
| BOWIE | | 20 | 80 | 2,800.00 | 85 |
| BOWIE | | | | | 86 |
| BOWIE | TP-20 | 20 | 80 | 3,000.00 | 85 |
| BOWIE | TP-20 | 20 | 80 | 2,795.00 | 84 |
| BOWIE | | 20 | 80 | 2,400.00 | 82 |
| BOWIE (TANAKA) | TP 202 | 13 | 70 | 1,500.00 | 84 |
| FISCHER | | 20 | 90 | 4,000.00 | 83 |
| KRAMEX | PX20N | 20 | 80 | 2,300.00 | 84 |
| KRAMEX | | 20 | 80 | 3,200.00 | 81 |
| KRAMEX | PX 20N | 20 | 80 | 2,500.00 | 80 |
| KRAMEX | DX 30N | 30 | 100 | 4,095.00 | 83 |
| KRAMEX | | 20 | 80 | | 85 |
| KRAMEX | | 20 | 90 | 4,000.00 | 86 |
| KRAMEX | PR 8020 | 20 | 80 | 3,000.00 | 85 |
| KRAMEX | PX-20N | 20 | 80 | | 86 |
| KRAMEX | | 20 | 80 | 3,000.00 | 80 |
| KRAMEX | | 20 | 80 | 3,000.00 | 80 |
| KRAMEX | | 20 | 80 | 3,000.00 | 80 |
| KRAMEX | | 20 | 80 | 3,000.00 | 80 |
| KRAMEX | DX30N | 30 | 100 | 4,000.00 | 84 |
| KRAMEX | PX 30N | 20 | 80 | | 85 |
| KRAMEX 80 | PX 20N | 20 | 80 | 3,500.00 | 85 |
| MIN X RAY | 300 | 30 | 90 | 3,500.00 | 85 |
| MIN X RAY | 300 (A) | 30 | 90 | 3,500.00 | 82 |
| minimum | | 13 | 70 | 1,500.00 | |
| maximum | | 30 | 100 | 4,095.00 | |
| mean | | 21 | 83 | 3,075.71 | |

TABLE IV

PORTABLE UNITS PURCHASED USED PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| BOWIE | | | | | |
| FISCHER | | | | | |
| MIN X RAY | | 15 | 63 | | 74 |
| PICKER | ARMY | 100 | 100 | 1,500.00 | 73 |
| PICKER | TYPE 793 | 90 | 100 | 650.00 | 71 |
| PROFEXRAY | | | | 30.00 | |
| PROFEXRAY | A | 20 | 80 | | 57 |
| PROFEXRAY | F-1A | 20 | 80 | 500.00 | 75 |
| PROFEXRAY | A | 20 | 80 | 5.00 | 79 |
| PROFEXRAY | | 20 | 80 | 500.00 | 75 |
| PROFEXRAY | OLD | 15 | 80 | 250.00 | 72 |
| UNIVERSAL | | 30 | 100 | | 66 |
| minimum | | 15 | 63 | 5.00 | |
| maximum | | 100 | 100 | 1,500.00 | |
| mean | | 37 | 85 | 490.71 | |

TABLE V

PORTABLE UNITS PURCHASED USED AFTER JANUARY 1, 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| | | | | 1,500.00 | 83 |
| | | 100 | 100 | 500.00 | 81 |
| BOWIE | | 20 | 80 | | 86 |
| BOWIE | | | | 2,100.00 | 85 |
| FISCHER | TC-50 | 50 | 100 | 2,200.00 | 84 |
| GENERAL ELECTRIC | 11CD2-2 | 15 | 90 | | 82 |
| GENERAL ELECTRIC | 90 TYPE 2 | 15 | 90 | 1,800.00 | 82 |
| GENERAL ELECTRIC | D TYPE 3 | | | 350.00 | 82 |
| MIN X RAY | 110 | 13 | 68 | 1,800.00 | 83 |
| PICKER | 43 | 100 | 100 | 3,000.00 | 84 |
| PROFEXRAY | | 20 | 80 | 400.00 | 84 |
| PROFEXRAY | VERY OLD | 20 | 80 | | 80 |
| PROFEXRAY | A | 20 | 80 | 550.00 | 81 |
| SEREND | 20 | 15 | 63 | 750.00 | 82 |
| SEREND | SEREND 20 | 15 | 63 | 500.00 | 85 |
| minimum | | 13 | 63 | 350.00 | |
| maximum | | 100 | 100 | 3,000.00 | |
| mean | | 34 | 83 | 1,287.50 | |

TABLE VI

PORTABLE UNITS NOT CLASSIFIED

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| DIAGNOSTIC X-RAY | MT-40 | 50 | 100 | | |
| MIN X RAY | | 15 | 63 | | |
| MIN X RAY | | 15 | 63 | | |
| MIN X RAY | | 15 | 63 | | |
| PICKER | | | | | |
| PROFEXRAY | 227-T | 20 | 80 | | |
| SEREND | 20 | | | | |
| minimum | | 15 | 63 | 0.00 | |
| maximum | | 50 | 100 | 0.00 | |
| mean | | 23 | 74 | | |

TABLE VII

MOBILE UNITS PURCHASED NEW PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| UNIVERSAL | MOBILMASTR | 25 | 95 | | 50 |
| minimum | | 25 | 95 | 0.00 | |
| maximum | | 25 | 95 | 0.00 | |
| mean | | 25 | 95 | | |

TABLE VIII

MOBILE UNITS PURCHASED NEW AFTER JANUARY 1, 1987

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| UNIVERSAL | | 30 | 90 | | 85 |
| UNIVERSAL | MBLMSTR 30 | 30 | 95 | 3,065.00 | 80 |
| minimum | | 30 | 90 | 3,065.00 | |
| maximum | | 30 | 95 | 3,065.00 | |
| mean | | 30 | 93 | 3,065.00 | |

TABLE IX

MOBILE UNITS PURCHASED USED PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| CONTINENTAL | EH-S | 60 | 100 | 1,200.00 | 79 |
| FISCHER | TG-50 | 50 | 100 | 1,200.00 | 76 |
| FISCHER | TC-30 | 30 | 100 | 500.00 | 79 |
| FISCHER | L-11-046 | 40 | 100 | 900.00 | 79 |
| FISCHER | SS-30 | 25 | 120 | 2,700.00 | 75 |
| FISCHER | L-11046 | 40 | 100 | 900.00 | 79 |
| GENERAL ELECTRIC | | 15 | 90 | | 72 |
| GENERAL ELECTRIC | 11AA2-3 | 15 | 90 | | |
| GENERAL ELECTRIC | TYPE 88 | 12 | 140 | | 64 |
| GENERAL ELECTRIC | D-2 | 30 | 90 | 750.00 | 76 |
| KELLY-KOETT | | 100 | 100 | 1,500.00 | 72 |
| PICKER | | 300 | 120 | | 79 |
| PICKER | | 200 | 130 | 4,500.00 | 76 |
| PROFEXRAY | MI-A | 20 | | | 78 |
| PROFEXRAY | | 20 | 80 | 300.00 | |
| PROFEXRAY | 14-1A | 15 | | 750.00 | 79 |
| PROFEXRAY | | 25 | 100 | | 77 |
| TOSHIBA | KCD-10-M | 50 | 100 | | |
| UNIVERSAL | A 4G1 ? | 25 | 100 | 500.00 | 64 |
| UNIVERSAL | EASYMATIC | 100 | 100 | | |
| UNIVERSAL | | | | 500.00 | 79 |
| minimum | | 12 | 80 | 300.00 | |
| maximum | | 300 | 140 | 4,500.00 | |
| mean | | 59 | 103 | 1,246.15 | |

TABLE X

MOBILE UNITS PURCHASED USED AFTER JANUARY 1, 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| CGR | UZ260PSPG | 250 | 120 | 5,000.00 | 86 |
| CONTINENTAL | EH-5 | 40 | 90 | 1,600.00 | 84 |
| FISCHER | TC-20 | 30 | 90 | | 83 |
| GENERAL ELECTRIC | | 100 | 90 | 1,500.00 | 81 |
| GENERAL ELECTRIC | GE 100 | 30 | 100 | 500.00 | 80 |
| PICKER | 6139 | 300 | 120 | 4,000.00 | 80 |
| PICKER | ANTIQUE | 30 | 90 | 2,600.00 | 86 |
| PICKER | | 100 | | 3,000.00 | 83 |
| PICKER | | 30 | 90 | 1,500.00 | 86 |
| PROFEXRAY | | 20 | 80 | 500.00 | 86 |
| PROFEXRAY | OLD | 20 | 80 | | 82 |
| PROFEXRAY | | 25 | 120 | 150.00 | 85 |
| PROFEXRAY | A-400 | 20 | 80 | 600.00 | 82 |
| STANDARD | | 200 | 100 | 1,000.00 | 84 |
| UNIVERSAL | 3720 | 30 | 100 | 6,000.00 | 83 |
| WESTINGHOUSE | OLD | 20 | 90 | 600.00 | 81 |
| minimum | | 20 | 80 | 150.00 | |
| maximum | | 300 | 120 | 6,000.00 | |
| mean | | 78 | 96 | 2,039.28 | |

TABLE XI

MOBILE UNITS NOT CLASSIFIED

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| PHILLIPS | 11056 | 30 | 95 | | |
| PICKER | ARMY | 90 | 100 | 1,200.00 | 81 |
| UNIVERSAL | 3205-100 | 50 | 80 | 1,500.00 | 70 |
| WESTINGHOUSE | MILITARY | 100 | 100 | | |
| X?X? | | 200 | 130 | | |
| minimum | | 30 | 80 | 1,200.00 | |
| maximum | | 200 | 130 | 1,500.00 | |
| mean | | 94 | 101 | 1,350.00 | |

TABLE XII

FIXED UNITS PURCHASED NEW PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| EUREKA (LITTON) | RA 59 | 100 | 100 | | 74 |
| FISCHER | 36600G | 300 | 125 | | 77 |
| FISCHER | LES-300 | 300 | 125 | 7,637.50 | 74 |
| FISCHER | LFS-300 | 300 | 125 | 7,637.00 | 74 |
| MIN X RAY | 300 | 30 | 100 | | 70 |
| UNIVERSAL | | 30 | 100 | 1,500.00 | 60 |
| UNIVERSAL | 3360 | 60 | 100 | | 68 |
| minimum | | 30 | 100 | 1,500.00 | |
| maximum | | 300 | 125 | 7,637.50 | |
| mean | | 160 | 110 | 5,591.50 | |

TABLE XIII

FIXED UNITS PURCHASED NEW AFTER JANUARY 1, 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| BENNETT | C-325-S | 300 | 120 | 13,000.00 | 85 |
| BENNETT | C8355 | 300 | 125 | 1,500.00 | 80 |
| BENNETT | B-6606B | 300 | 125 | 12,560.00 | 85 |
| BENNETT | C-3255 | 300 | 125 | 17,000.00 | 85 |
| BENNETT | | 300 | 125 | | 83 |
| TRANSWORLD | 325 V | 300 | 120 | 12,000.00 | 80 |
| UNIVERSAL | 6061 | 300 | 125 | | 86 |
| UNIVERSAL | EASYMATIC | 300 | 125 | 8,000.00 | 86 |
| UNIVERSAL | EASYMATIC | 300 | 125 | 8,300.00 | 84 |
| UNIVERSAL | EASYMATIC | 300 | 100 | 8,000.00 | 80 |
| UNIVERSAL | EASYMATIC | 300 | 125 | 8,700.00 | 80 |
| UNIVERSAL | | 300 | 100 | 7,500.00 | 85 |
| UNIVERSAL | ESYMTC 325 | 300 | 125 | 7,600.00 | 85 |
| minimum | | 300 | 100 | 1,500.00 | |
| maximum | | 300 | 125 | 17,000.00 | |
| mean | | 300 | 120 | 9,469.09 | |

TABLE XIV

FIXED UNITS PURCHASED USED PRIOR TO 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| FISCHER | M-11 | | | | |
| FISCHER | TF | 30 | 85 | | |
| FISCHER | TC | 30 | 100 | | |
| GENERAL ELECTRIC | MAXICON | 200 | 90 | 3,000.00 | 76 |
| GENERAL ELECTRIC | R-2 | 100 | 75 | 1,000.00 | 75 |
| GENERAL ELECTRIC | SMC-1940 | 200 | 100 | 1,300.00 | 76 |
| GENERAL ELECTRIC | YR 39 | | 94 | | 70 |
| GENERAL ELECTRIC | KX-11 (5) | 200 | 100 | 2,600.00 | 76 |
| GENERAL ELECTRIC | MAXICON | 200 | 90 | 3,500.00 | 76 |
| GENERAL ELECTRIC | R TYPE-4 | 100 | 90 | | |
| GENERAL ELECTRIC | | 200 | 100 | 1,000.00 | 78 |
| GENERAL ELECTRIC | 11CK2-1 | 300 | 125 | 5,000.00 | 75 |
| GENERAL ELECTRIC | | 100 | 82 | | |
| GENERAL ELECTRIC | | 100 | 100 | 1,500.00 | 70 |
| MACHLETT LABS | PROF/DYX40 | 100 | 100 | 2,600.00 | 77 |
| PICKER | | 200 | 100 | 500.00 | 75 |
| PICKER | R-1 | 100 | 100 | | 79 |
| PROFEXRAY | A409 | 20 | 85 | 250.00 | 79 |
| PROFEXRAY | OLD | 100 | | 1,000.00 | 74 |
| PROFEXRAY | | 20 | 80 | 600.00 | 62 |
| PROFEXRAY | TC-2 | 20 | 80 | | 70 |
| PROXERAY | R 305-2S | 300 | 100 | | 71 |
| STANDARD | E | 110 | 100 | 750.00 | 73 |
| UNIVERSAL | A 555 | 30 | 100 | 200.00 | 72 |
| UNIVERSAL | 337-S | 20 | 120 | 50.00 | 60 |
| WAPPLER | YR 1938 | 100 | 100 | 450.00 | 56 |
| WESTINGHOUSE | DIAFLEX 60 | 200 | 125 | 4,500.00 | 75 |
| WESTINGHOUSE | | 300 | 125 | 8,500.00 | 79 |
| WESTINGHOUSE | OLD HUMAN | 100 | 100 | 5,000.00 | 62 |
| WESTINGHOUSE | 981625?Y48 | 200 | 100 | 1,500.00 | 78 |
| WESTINGHOUSE | | 200 | | 2,500.00 | 73 |
| WESTINGHOUSE | 981475 | 100 | 100 | 1,500.00 | 79 |
| minimum | | 20 | 75 | 50.00 | |
| maximum | | 300 | 125 | 8,500.00 | |
| mean | | 132 | 98 | 2,121.73 | |

TABLE XV

FIXED UNITS PURCHASED USED AFTER JANUARY 1, 1980

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| CONTINENTAL | JB-AS | 200 | 100 | 2,000.00 | 80 |
| CONTINENTAL | EH | 10 | 70 | 2,000.00 | 83 |
| FISCHER | SS75 /SS22 | 500 | 100 | 2,500.00 | 86 |
| FISCHER | TG-50 | 50 | 100 | 2,000.00 | 81 |
| GENERAL ELECTRIC | | | | 800.00 | 81 |
| MATTERN | | 100 | 100 | 750.00 | 81 |
| PROFEXRAY | | 100 | 100 | 4,500.00 | 80 |
| PROFEXRAY | TC 3 | 100 | 100 | 3,885.00 | 85 |
| PROFEXRAY | | 100 | 100 | 3,000.00 | 81 |
| STANDARD | | 400 | 125 | 7,000.00 | 83 |
| UNIVERSAL | 3205 | 30 | 80 | 1,200.00 | 84 |
| WESTINGHOUSE | 981625 | 200 | 100 | 600.00 | 84 |
| WESTINGHOUSE | AUTOFLEX | 200 | 130 | 2,000.00 | 85 |
| WESTINGHOUSE | XO 4790 | 200 | 90 | 4,000.00 | 83 |
| WESTINGHOUSE | WESTEX | 200 | 100 | 3,400.00 | 84 |
| WESTINGHOUSE | DYNAMAX | 200 | 110 | | 81 |
| minimum | | 10 | 70 | 600.00 | |
| maximum | | 500 | 130 | 7,000.00 | |
| mean | | 173 | 100 | 2,642.33 | |

TABLE XVI

FIXED UNITS NOT CLASSIFIED

| RADIOGRAPHIC UNIT | MODEL | max. mA | max. kVp | COST $ | YR. PURCHASED |
|---|---|---|---|---|---|
| GENERAL ELECTRIC | 48 (1) | 90 | 90 | | |
| PICKER | PRE WW II | | 100 | | |
| UNIVERSAL | | 30 | 80 | | 65 |
| minimum | | 30 | 80 | 0.00 | |
| maximum | | 90 | 100 | 0.00 | |
| mean | | 60 | 90 | | |

TABLE XVII

RADIOGRAPHIC FILMS BY MANUFACTURER

| MANUFACTURER | COUNT | PERCENTAGE |
|---|---|---|
| DUPONT | 24 | 19.83 |
| FUJI | 6 | 4.96 |
| FR MEDICAL | 1 | 0.83 |
| GEVART | 1 | 0.83 |
| KONICA | 2 | 1.65 |
| POLAROID | 3 | 2.48 |
| RS-90 | 1 | 0.83 |
| SAKURA | 2 | 1.65 |
| SUPERIOR | 1 | 0.83 |
| 3M | 47 | 38.84 |
| DUPONT/3M | 2 | 1.65 |
| KODAK/DUPONT | 4 | 3.31 |
| KODAK/FUJI | 2 | 1.65 |
| KODAK/3M | 9 | 7.44 |
| 3M/FUJI | 5 | 4.13 |
| 3M/KONICA | 1 | 0.83 |
| KODAK/DUPONT/KONICA | 1 | 0.83 |
| KODAK/DUPONT/3M | 2 | 1.65 |
| KODAK/3M/FUJI | 1 | 0.83 |
| KODAK/DUPONT/3M/FUJI | 4 | 3.31 |
| NOT IDENTIFIED | 2 | 1.65 |
| TOTAL | 121 | |

TABLE XVIII

RADIOGRAPHIC SCREENS BY MANUFACTURER

| MANUFACTURER | COUNT | PERCENTAGE |
|---|---|---|
| BARRAY | 1 | 0.86 |
| DUPONT | 54 | 46.55 |
| FISCHER | 2 | 1.72 |
| FUJI | 2 | 1.72 |
| HALSEY | 1 | 0.86 |
| KODAK | 38 | 32.76 |
| POLAROID | 1 | 0.86 |
| SAKURA | 1 | 0.86 |
| SPECTRA | 1 | 0.86 |
| US RADELIN | 1 | 0.86 |
| 3M | 10 | 8.62 |
| DUPONT/3M | 2 | 1.72 |
| KODAK/DUPONT | 1 | 0.86 |
| KODAK/DUPONT/3M | 1 | 0.86 |
| TOTAL | 116 | |

TABLE XIX

RADIOGRAPHIC FILM/SCREEN SPEEDS

| SPEED | COUNT | PERCENTAGE |
|---|---|---|
| RARE EARTH | 38 | 43.18 |
| HI PLUS | 22 | 25.00 |
| PAR | 19 | 21.59 |
| RARE EARTH or PAR | 1 | 1.14 |
| RARE EARTH or HI PLUS | 3 | 3.41 |
| HI PLUS or PAR | 3 | 3.41 |
| HI SPEED | 1 | 1.14 |
| TF-2 | 1 | 1.14 |

TABLE XX

RADIOGRAPHIC FILM/SCREEN - SPEED VS. EQUIPMENT

| | PAR | HI PLUS | RARE EARTH |
|---|---|---|---|
| PORTABLE | 5 | 25 | 16 |
| MOBILE | 8 | 12 | 14 |
| FIXED | 10 | 20 | 10 |

TABLE XXI

MEAN VALUES OF REPORTED RADIOGRAPHIC TECHNIQUES
FOR SMALL ANIMAL THORAX

| | | | |
|---|---|---|---|
| PORTABLE | | | |
| mA | 10 - 100 | 23.237 | (7.92 avg. mAs) |
| time | 0.02 - 1.50 | 0.341 | |
| kVp | 50 -90 | 68.27 | |
| distance | 16 - 47 | 32.87 | |
| grid | yes = 4 | no = 18 | |
| MOBILE | | | |
| mA | 10 - 200 | 48.485 | (16.00 avg. mAs) |
| time | 0.01 - 3.00 | 0.330 | |
| kVp | 10 - 86 | 62.29 | |
| distance | 20 - 40 | 31.38 | |
| grid | yes = 1 | no = 18 | |
| FIXED | | | |
| mA | 5 - 300 | 134.226 | (19.60 avg. mAs) |
| time | 0.01 - 1.50 | 0.146 | |
| kVp | 34 - 106 | 68.492 | |
| distance | 20 - 63 | 36.11 | |
| grid | yes = 23 | no = 17 | |

TABLE XXII

MEAN VALUE OF REPORTED RADIOGRAPHIC TECHNIQUES
FOR SMALL ANIMAL PELVIS

| | | | |
|---|---|---|---|
| PORTABLE | | | |
| mA | 10 - 100 | 23.568 | (8.86 avg. mAs) |
| time | 0.02 - 1.20 | 0.376 | |
| kVp | 50 - 100 | 68.11 | |
| distance | 16 - 45 | 31.87 | |
| grid | yes = 4 | no = 11 | |
| MOBILE | | | |
| mA | 10 - 200 | 40.469 | (16.11 avg. mAs) |
| time | 0.03 - 3.00 | 0.398 | |
| kVp | 10 -80 | 60.806 | |
| distance | 20 - 40 | 31.38 | |
| grid | yes = 1 | no = 16 | |
| FIXED | | | |
| mA | 5 - 300 | 132.049 | (22.32 avg. mAs) |
| time | 0.01 - 1.50 | 0.169 | |
| kVp | 34 - 100 | 67.30 | |
| distance | 20 -63 | 35.74 | |
| grid | yes = 26 | no = 12 | |

TABLE XXIII

MEAN VALUES OF REPORTED RADIOGRAPHIC TECHNIQUES
FOR LARGE ANIMAL CARPUS

| | | | |
|---|---|---|---|
| PORTABLE | | | |
| mA | 10 - 100 | 21.658 | ( 8.69 avg. mAs) |
| time | 0.02 - 2.5 | 0.401 | |
| kVp | 43 - 85 | 70.333 | |
| distance | 14 - 54 | 30.290 | |
| grid | yes = 1 | no = 18 | |
| MOBILE | | | |
| mA | 10 -200 | 43.611 | (12.12 avg. mAs) |
| time | 0.02 - 0.75 | 0.278 | |
| kVp | 50 - 100 | 69.267 | |
| distance | 24 - 40 | 32.50 | |
| grid | yes = 0 | no = 10 | |
| FIXED | | | |
| mA | 10 - 300 | 124.000 | (34.47 avg. mAs) |
| time | 0.02 - 1.00 | 0.278 | |
| kVp | 55 - 74 | 63.200 | |
| distance | 30 - 40 | 35.00 | |
| grid | yes = 1 | no = 4 | |

TABLE XXIV

RADIOGRAPHIC FILM PROCESSING

| Processing | Count | Percentage |
|---|---|---|
| MANUAL | 147 | 86.47 |
| AUTOMATIC | 12 | 7.06 |
| OUTSIDE | 11 | 6.47 |

TABLE XXV

MEAN VALUES FOR MANUAL PROCESSING DATA

| | TEMPERATURE | TIME | |
|---|---|---|---|
| | | DEVELOPER | FIXER |
| MINIMUM | 58 | 1.5 | 1.0 |
| MAXIMUM | 83 | 8.0 | 20.0 |
| MEAN | 70 | 4.3 | 7.1 |

TABLE XXVI

AUTOMATIC PROCESSOR DATA

| MANUFACTURER | MODEL | NEW/USED | COST | YEAR PURCHASED |
|---|---|---|---|---|
| AFP | COMPACT | NEW | 4200.00 | 84 |
| ALPHA TEX | AX 600 | USED | | 81 |
| BOWIE | POLAROID | NEW | 800.00 | 82 |
| FILMAMATIC | F 140 | NEW | 5000.00 | 80 |
| FISCHER | | NEW | 5000.00 | 83 |
| G.E. | FILMATIC | NEW | 4500.00 | 70 |
| KONICA | QK-60A | NEW | | 85 |
| LITTON | INDEPENDENT | USED | 500.00 | |
| POLAROID | 85-12 | NEW | 1000.00 | 85 |
| POLAROID | | USED | | 86 |
| SAKURA | QX 60 | NEW | | 81 |
| | F 120 | NEW | 4000.00 | 80 |
| MINIMUM | | | 500.00 | |
| MAXIMUM | | | 5000.00 | |
| MEAN | | | 3500.00 | |
| MEAN (USED) | | | 500.00 | |

TABLE XXVII

RADIATION PROTECTION DATA

| | | | |
|---|---|---|---|
| PERSONNEL MONITORING: | | | |
| FILM BADGE | 80 (yes) | | 1 (no) |
| TLD | 23 (yes) | | 1 (no) |
| COUNT | 103 | | 2 |
| INDIVIDUAL BADGES | 85 (yes) | | |
| GROUP BADGES | 5 (yes) | | |
| CHANGING PERIOD | | | |
| WEEKLY | 40 film badge | | 4 TLD |
| MONTHLY | 40 film badge | | 9 TLD |
| QUARTERLY | 2 film badge | | |
| USEAGE OF LEAD APRONS & GLOVES | | | |
| | 169 (yes) | | 4 (no) |
| INSPECTION by OKLAHOMA DEPARTMENT OF HEALTH | | | |
| | 124 (yes) | | 35 (no) |

TABLE XXVIII

CHARGES FOR SELECTED EXAMINATIONS

| | SMALL ANIMAL THORAX ( 2 - VIEWS) | SMALL ANIMAL PELVIS ( 2 - VIEWS) | LARGE ANIMAL CARPUS ( 2 - VIEWS) |
|---|---|---|---|
| MINIMUM | 12.50 | 12.50 | 12.50 |
| MAXIMUM | 67.50 | 67.50 | 50.00 |
| MEAN | 32.50 | 32.50 | 29.37 |

TABLE XXIX

MISCELLANEOUS RESPONSE TO SURVEY

COMMENTS ON RADIOLOGY SERVICE NOT AVAILABLE

COUNT = 57

Examples of comments:
- Retired
- Federal worker
- Industrial worker
- Graduate student
- Relief veterinarian
- Inactive
- Refer radiology cases

DUPLICATE RECORDS RECEIVED FROM FACILITIES

COUNT = 24

SURVEY DATA REVEALS MORE THAN ONE UNIT

2 UNITS IN PRACTICE

COUNT = 16

3 UNITS IN PRACTICE

COUNT = 2

4 UNITS IN PRACTICE

COUNT = 1

# APPENDIX B

## LETTER FROM DEAN AND RADIOLOGIST

OSU

Oklahoma State University

COLLEGE OF VETERINARY MEDICINE
BOREN VETERINARY MEDICAL TEACHING HOSPITAL

STILLWATER, OKLAHOMA 74078
(405) 624-7000 Administration
(405) 624-6656 (Large Animal)
(405) 624-6731 (Small Animal)
(405) 624-6735 (Radiology)

April 15, 1986

Dear OVMA Member;

The College of Veterinary Medicine is cooperating with a research project to determine what type of radiographic equipment and what type of radiographic procedures are being used at veterinary clinics throughout Oklahoma.

The research project provides a survey form for identification of radiographic usage. Your clinic/hospital is one of five-hundred facilities selected to participate in the survey. You will be asked to supply information about the type of radiographic equipment, accessory equipment, technique, processing, radiation safety and radiographic fee's.

Enclosed is the survey form which you are asked to fill out as accurately as possible and return in the postage prepaid envelope by August 15, 1986. Richard Smith, who is conducting the survey in fulfillment of his master thesis in Technical Education, will be collecting and analyzing the data.

We believe that the data accumulated in this research project will provide helpful information that can, in turn, be useful in instruction of our veterinary students. Your cooperation in providing the needed data will ensure the completion of the project.

R.J. Bahr

Robert J. Bahr, DVM
Associate Professor
Veterinary Radiology

J.W. Alexander

Joseph W. Alexander, DVM
Professor and Dean

CENTENNIAL DECADE
1980 • 1990

# APPENDIX C

## LETTER OF EXPLANATION ON SURVERY

OSU

Oklahoma State University

COLLEGE OF VETERINARY MEDICINE
BOREN VETERINARY MEDICAL TEACHING HOSPITAL

STILLWATER, OKLAHOMA 74078
(405) 624-7000 Administration
(405) 624-6656 (Large Animal)
(405) 624-6731 (Small Animal)
(405) 624-6735 (Radiology)

April 15, 1986

Dear OVMA Member;

The questionnaire on the back of this letter is to gather data on the use of radiology in veterinary clinics. It has a two-fold purpose: 1) to provide information on radiographic equipment and radiographic procedure for formal presentation in VMS 6531 (Radiology I), and 2) to provide research data for preparation of a master's thesis in Technical Education. I am acutely aware of the time constraints on the busy professional. If there is not time available in your schedule to complete the questionnaire, please draw an "X" thru the questionnaire and return it in the postage prepaid envelope. This will allow me to assess the distribution return rate for statistical evaluation.

In completing the questionnaire, please respond only to those items that directly relate to your practice. The office phone number will be the means by which to identify the respondants and should allow a check for duplication of information. Information in the report format will not identify respondants and fee schedules will be collectively summed to determine an average fee.

Please allow me the opportunity of thanking you in advance for your assistance in this project. It would be appreciated if you would return the questionnaire no later than August 15, 1986.

Respectfully,

H. Richard Smith

H. Richard Smith
Manager Radiology Service

CENTENNIAL DECADE 1980 • 1990

# APPENDIX D

## EXAMPLE OF SURVEY INSTRUMENT

CLINIC/HOSPITAL _____

CITY _____ ZIP _____

OFFICE PHONE (___) _____-_____

( ) RADIOLOGY SERVICES NOT AVAILABLE AT THIS FACILITY

1. RADIOGRAPHIC UNIT # 1
   Manufacturer: _____
   Model: _____
   Type: portable( ) mobile ( ) fixed ( )
   Year purchased: 19___ new ( ) used ( ) $ _____
   Max. mA _____ Max. kVp _____
   Collimation: fixed ( ) variable ( ) none ( )

   RADIOGRAPHIC UNIT # 2
   Manufacturer: _____
   Model: _____
   Type: portable( ) mobile ( ) fixed ( )
   Year purchased: 19___ new ( ) used ( ) $ _____
   Max. mA _____ Max. kVp _____
   Collimation: fixed ( ) variable ( ) none ( )

2. RADIOGRAPHIC FILM & INTENSIFYING SCREENS

| | | | |
|---|---|---|---|
| Kodak | ( ) | Kodak | ( ) |
| Dupont | ( ) | Dupont | ( ) |
| 3 M | ( ) | 3 M | ( ) |
| Fuji | ( ) | Fuji | ( ) |
| Other | _____ | Other | _____ |

   Calcium tungstate screens: hi plus ( ) par ( )
   Rare earth screens ( )

3. RADIOGRAPHIC TECHNIQUE

   Small Animal-Thorax - Lateral view - 15cm

   ___mA ___time ___kVp ___distance grid (y)(n)

   Small Animal-Pelvis - Ventrodorsal - 12cm

   ___mA ___time ___kVp ___distance grid (y)(n)

   Large Animal-Carpus - Dorsopalmar/AP-10cm

   ___mA ___time ___kVp ___distance grid (y)(n)

4. PROCESSING: Automatic
   Manufacturer: _____
   Model: _____
   Year purchased: 19___ new( ) used( ) $____

   PROCESSING: Manual
   Working Temperature ___F°
   Developing Time _____minutes
   Fixing Time _____minutes

   PROCESSED BY OUTSIDE SOURCE ( )

5. RADIATION MONITORING
   Film Badge ( ) TLD Badge ( )
   Changing Period:weekly( )Monthly( )Quarterly( )
   Individual badges ( ) Group Badges ( )

   Lead aprons and gloves available and used:
   yes ( ) no ( )

   Surveyed by: Radiation Control Section
   Oklahoma - Dept. of Health
   yes ( ) no ( )
   date of last survey ____/____
   mo yr

6. CHARGES for RADIOGRAPHY

   2 views - Small Animal Thorax $ _____

   2 views - Small Animal Pelvis $ _____

   2 views - Large Animal Carpus $ _____

VITA

Henry Richard Smith

Candidate for the Degree of

Master of Science

Thesis: SURVEY OF THE PRACTICE OF RADIOLOGY IN VETERINARY CLINICS IN THE STATE OF OKLAHOMA-1986

Major Field: Technical Education

Biographical:

Personal Data: Born in Tulsa, Oklahoma, May 7, 1946.

Education: Graduated from Blackwell High School, Blackwell, Oklahoma, May, 1964; received Associate of Science degree in Radiation and Nuclear Technology from Oklahoma State University, May, 1969; received Bachelor of Science degree in Engineering Technology from Oklahoma State University, May, 1981; completed the requirements for Master of Science degree at Oklahoma State University in July, 1987.

Professional Experience: Radiation Health Specialist, University of Nebraska, May, 1969 to October, 1972; Assistant Instructor in Allied Health, University of Nebraska Medical Center, November, 1972 to May, 1975; Technical Supervisor, Veterinary Radiology, Oklahoma State University, June, 1975 - January, 1982; System Coordinator, Medical Imaging, Scanline, Inc., February, 1982 to February, 1984; Manager, Radiology Service Boren Veterinary Teaching Hospital, March, 1983 to present.