JOURNAL OF THE SOCIETY OF PETROLEUM EVALUATION ENGINEERS

1968-1969

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OFFICERS AND DIRECTORS

1963  Organizing Directors
   Harold Vance, President
   William Hurst, Vice President
   Herbert F. Poyner, Jr., Secretary-Treasurer

1964  Directors and Officers
   H. J. Gray, President
   Jack Crichton, Vice President
   Harry L. Dedman, Secretary-Treasurer
   K. M. Fagin, Director
   Harold Vance, Director
   William Hurst, Director
   Herbert F. Poyner, Jr., Director

1965  Directors and Officers
   Jack Crichton, President
   C. H. Keplinger, Vice President
   Thomas M. Burch, Jr., Secretary-Treasurer
   Roger Hamel, Director
   H. J. Gray, Director
   K. M. Fagin, Director
   Harry L. Dedman, Director

1967  Directors and Officers
   J. J. Arps, President
   Fred L. Oliver, Vice President
   Frank E. McGonagill, Jr., Secretary-Treasurer
   Wallace O. Keller, Director
   J. Donald Clark, Director
   Jerome J. O'Brien, Director
   Gerald E. Sherrod, Director

1966  Directors and Officers
   C. H. Keplinger, President
   Roger Hamel, Vice President
   Thomas M. Burch, Jr., Secretary-Treasurer
   Frank E. McGonagill, Jr., Director
   Fred L. Oliver, Director
   Wallace O. Keller, Director
   J. J. Arps, Director

1968  Directors and Officers
   George W. Taylor, President
   Norman J. Clark, Vice President
   J. Donald Clark, Secretary-Treasurer
   T. W. McGuiire, Director
   Jerome J. O'Brien, Director
   Gerald E. Sherrod, Director
   William H. Spice, Jr., Director

1969  Directors and Officers
   T. W. McGuire, President
   A. M. Derrick, Jr., Vice President
   Walter P. Jensen, Jr., Secretary-Treasurer
   Norman J. Clark, Director
   A. E. Smith, Director
   Wm. H. Spice, Jr., Director
   George W. Taylor, Director
HISTORY

There has long been a need for a Society which would bring together for their mutual benefit the specialists in petroleum evaluation engineering. Realizing this need, Harold Vance, William Hurst and H. F. Poyner, Jr. secured a charter from the State of Texas for such a Society which is known as “The Society of Petroleum Evaluation Engineers.” The number of the charter setting up such a corporation is No. 187232 and was issued by the Secretary of the State of Texas on September 24, 1962.

This corporation was chartered under the Texas Non-Profit Corporation Act and its period of duration is perpetual. The corporation was organized exclusively for educational purposes and to promote the profession of petroleum evaluation engineering, to foster the spirit of scientific research among its members, and to disseminate facts pertaining to petroleum evaluation engineering among its members and the public.

The various, technical associations, such as the American Institute of Mining, Metallurgical, and Petroleum Engineers, the American Association of Petroleum Geologists, and even the requirements of our engineering laws, provide no measure of the experience and ability of an individual in petroleum evaluation. Therefore, a need for this specialized Society is self-evident.
MEMBER QUALIFICATIONS

Any person with a bachelor's or advanced degree in engineering or geology, duly licensed by his state as a professional engineer or geologist and ten years' experience in the evaluation of oil and gas properties may qualify to become a member. In the event his state has no professional engineering or geological license laws, the person shall be able to meet the requirements for a license in either of these categories in another state having such laws. Also, a person may substitute five years' responsible petroleum engineering experience or teaching of the subject in a college or university of recognized standing for five years' experience in the evaluation of oil and gas properties.
August 28, 1969

Dear Fellow Engineers:

When I applied for membership in The Society of Petroleum Evaluation Engineers, I was proud to list as sponsors three of the founding fathers of the organization. But when it came to providing the names of three references, I was unable to comply with the parenthetical request on the application form, "preferably members of the Society," for the simple reason that there were not that many other members.

I thought I had a problem. But if I were to apply for membership today I would have a greater problem—how to select from the growing roster of outstanding engineers a mere six that I would most want to honor me with sponsorship and recommendation. It is with great humility that I speak of myself as President of the Society composed of you, the acknowledged best in petroleum evaluation.

As stated in the By-Laws of the Society, "the objects and purposes of this Society are to promote the profession of petroleum evaluation engineering, to foster the spirit of scientific research among its members, and to disseminate facts pertaining to petroleum evaluation engineering among its members and the public."

With this, our first annual transactions, we truly come of age; we disseminate information, we hope we challenge you to further research in these and related problems, we trust that each of you will share this volume with your associates and encourage them to join in our efforts to further improve the skills in petroleum evaluation engineering.

With kindest regards, I remain

Very truly yours,

T. W. McGuire
President of The Society of Petroleum Evaluation Engineers
Mr. T. W. McGuire of Shreveport, Louisiana, President of The Society of Petroleum Evaluation Engineers, 1968-1969
ARTICLE I. NAME

This Society, which is incorporated under the laws of the State of Texas, shall be called "The Society of Petroleum Evaluation Engineers."

ARTICLE II. OBJECTS

The objects and purposes of this Society are to promote the profession of petroleum evaluation engineering, to foster the spirit of scientific research among its members, and to disseminate facts pertaining to petroleum evaluation engineering among its members and the public.

ARTICLE III. MEMBERS

Any person with a bachelor’s or advanced degree in engineering or geology, duly licensed by his state as a professional engineer or geologist and ten years’ experience in the evaluation of oil and gas properties may qualify to become a member. In the event his state has no professional engineering or geological license laws, the person shall be able to meet the requirements for a license in either of these categories in another state having such laws. Also, a person may substitute five years’ responsible petroleum engineering experience or teaching of the subject in a college or university of recognized standing for five years’ experience in the evaluation of oil and gas properties.

Applications to become members must be approved and certified by the executive committee.

ARTICLE IV. ELECTION OF MEMBERS

SECTION 1. Every applicant for admission as a member shall submit an application on a form authorized by the executive committee, signed by him and endorsed by not less than three members who are in good standing. The applicant shall state his training and experience and such other facts as shall be prescribed from time to time by the executive committee, which shall screen the application, and acting in good faith with the applicant and his sponsors, determine whether or not he fulfills the qualifications required under Article III for presentation of his name and the names of his sponsors to the members.

If no objection is received within thirty (30) days after notification, the applicant shall be notified of his election.

If an objection is raised within 30 days after notification, the executive committee shall reconsider the application and determine whether to overrule the objection and elect the applicant or whether to drop the application.

If as many as five objections are received within the 30 day period, the executive committee must reject the application.

SECTION 2. An applicant, on being notified of his election in writing, shall pay dues applicable for the current year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days for those living elsewhere after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon election and payment of dues, each applicant shall be furnished with an appropriate identification card for the current year.

ARTICLE V. QUALIFICATIONS COMMITTEE

The executive committee may set up a qualifications committee, the purpose of which shall be to review such applications as may be referred to it by the executive committee, to recommend action to be taken with respect to applications so referred, to make a continuing study of requirements for admission to the Society, and when advisable to recommend to the executive committee changes in qualifications therefor. Unless a different number is authorized by the executive committee, the committee shall consist of nine members, at least three of whom shall be past officers.

ARTICLE VI. ETHICS

SECTION 1. Each member shall be guided by the highest standards of business ethics, personal honor, and professional conduct, as exemplified by the Canons of Ethics for Engineers as adopted by the Engineers’ Council for Professional Development. Honesty, integrity, loyalty, fairness, impartiality, candor, fidelity to trust, and inviolability of confidence are incumbent upon every member, not for submissive observance, but as a set of dynamic principles to guide a way of life.

SECTION 2. A member who, after due investigation, is found guilty of violating any of the standards prescribed in Section 1 of this article may be suspended, admonished, allowed to resign, or expelled from the Society in accordance with the procedure provided by the by-laws.

ARTICLE VII. BOARD OF DIRECTORS, OFFICERS AND THEIR DUTIES

SECTION 1. The organizing directors, Harold Vance, William Hurst, and H. F. Poyner, Jr., shall constitute the board of directors and the executive committee for the first year, January 1, 1963, to January 1, 1964, after which an additional four directors shall be elected to bring the board up to the seven members as authorized in the charter. Thereafter, the members shall select the board of directors consisting of seven members, with four new directors elected one year and three new directors elected the next year.

SECTION 2. A director may serve for two years and cannot be re-elected to the board until the lapse of two years after his tenure of office as a director. After January 1, 1964, there shall be no more than one member from any one company or organization elected to the board of directors. A vacancy occurring in the board of directors may be filled by an affirmative vote of a majority, though less than a quorum, of the remaining board of directors. A director elected to fill a vacancy shall be elected for the unexpired term of his predecessor in office.

SECTION 3. The board of directors shall elect from its members the following officers: president, vice president, and secretary-treasurer.

SECTION 4. The above-named officers and the immediate past-president shall constitute the executive committee.
SECTION 5. A nominating committee, to be appointed by the executive committee, within the month of September, shall nominate two members for each position as director. A petition signed by at least ten per cent of the members before September 1st may place a third name, or more, on the ballot along with the candidates selected by the nominating committee. The executive committee shall mail ballots to members during the first two weeks of October. Ballots shall be returned and counted by November 10.

SECTION 6. Each officer may serve for one year and shall not be eligible for re-election during his term of office as a director. However, should the board of directors so desire and should the Secretary-Treasurer be in agreement, then the Secretary-Treasurer may be re-elected for a second term during his term of office as a director. During any additional term as director any member who previously held office may, during this additional term, be re-elected an officer.

Duties of Officers

SECTION 7. The president shall be the presiding officer at all meetings of the Society, shall take cognizance of the acts of the Society, of its officers and staff, shall appoint, within the limitations prescribed by the by-laws, such committees as are required for the purpose of the Society, and shall delegate members to represent the Society. He shall serve as chairman of the executive committee.

SECTION 8. The vice president shall assume the office of the president in case of a vacancy in that office and shall assume the duties of president for such period or periods as that officer may be unable to perform his official duties.

SECTION 9. The secretary-treasurer shall assume the duties of president in case the president and vice president are unable to serve. The secretary-treasurer shall have charge of the financial affairs of the Society and shall annually submit reports covering the fiscal year. He shall receive all funds of the Society, and, under the direction of the executive committee, shall disburse all funds of the Society. He shall cause an audit to be prepared annually by a public accountant at the expense of the Society. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Society funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Society. The funds of the Society shall be disbursed by check as authorized by the executive committee.

SECTION 10. The officers shall assume the duties of their respective offices on January 1 following their election.

SECTION 11. A vacancy or disability occurring in the office of vice president or secretary-treasurer shall be filled by a majority vote of the executive committee, either for the unexpired term or for a shorter period of disability, as the committee may decide. In the case of a tie, the president shall cast the deciding vote.

ARTICLE VIII. EXECUTIVE COMMITTEE

SECTION 1. The executive committee shall consist of the president, immediate past-president, vice president, secretary-treasurer.

If the immediate past-president shall for any reason be unable to serve as a member of the executive committee, the president shall fill the vacancy by the appointment of the next available preceding past-president. If no past presidents are available to serve on the executive committee, the president shall appoint a director of the Society to serve on the executive committee in the place of a past-president of the Society.

SECTION 2. The executive committee shall have control and management of the affairs and funds of the Society. The executive committee shall determine the manner of publication and pass on the material presented for publication, shall designate the place and time of the annual meeting, shall appoint the nominating committee and its chairman, and shall be in charge of the annual election of officers and decide eligibility and other questions pertaining to the election. The executive committee is empowered to establish a business headquarters for the Society and to employ such persons as are needed to conduct the business of the Society. It is empowered to accept, create, and maintain special funds for publication, research and other purposes. It is empowered to make investments of both general and special funds of the Society and to create trust funds, giving to the trustees appointed for such purpose such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes.

ARTICLE IX. MEETINGS

SECTION 1. The board of directors may hold meetings either within or without the State of Texas. The first meeting of each newly elected board of directors shall be held at such time and place following its election as shall be fixed by the executive committee. Written or telegraphic notice of such meeting shall be given to each director at least five days before the date of the meeting. In the event the newly elected board of directors shall fail to hold such annual meeting, the officers for the ensuing year shall be elected by mail in such manner as may be determined by the executive committee. Special meetings of the board of directors may be called by the president or the secretary on the written request of two directors. Written or telegraphic notice of such special meetings of the board of directors shall be given to each director at least five days before the date of the meeting. Except as may be otherwise provided by statute or by the articles of incorporation, or by the by-law, neither the business to be transacted nor the purpose of any special meeting need be specified in a notice or waiver of notice. At all meetings of the board of directors a majority of the directors then in office shall constitute a quorum for the transaction of business, and the act of a majority of the directors present at any meeting at which their is a quorum shall be the act of the board of directors, except as may be otherwise specifically provided by statute or by the articles of incorporation.
SECTION 2. The executive committee consisting of the newly elected officers and the immediate past-president shall meet immediately preceding the annual meeting of members, which shall be held between November 10 and December 10, and at the call of the president may hold special meetings when and where advisable, to conduct the affairs of the Society. Executive committee members may vote by proxy on matters which require a unanimous vote. Written or telegraphic notice of meetings shall be given to each member of the committee at least five days before the date of a meeting. A majority of members of the committee represented in person or by proxy shall constitute a quorum for the transaction of business, and the act of a majority of the members present at any meeting at which there is a quorum present shall constitute the act of the executive committee.

SECTION 3. Any action of the board of directors or of the executive committee may be taken without a meeting if a consent in writing, setting forth the action so taken, shall be signed by all of the members of the board of directors or the executive committee, as the case may be; and such consent shall have the same force and effect as a unanimous vote of such board of directors or executive committee.

SECTION 4. The members shall hold at least one stated meeting each year, which shall be the annual meeting. The annual meeting shall be held at a time between November 10 and December 10 at a place designated by the executive committee. At this meeting Society business shall be transacted, scientific papers shall be read and discussed, and officers for the ensuing year shall be introduced. Special meetings of the members for any purpose or purposes, unless otherwise prescribed by statute or by the Articles of Incorporation, may be called by the president or the executive committee. A request for such a special meeting shall be directed to the secretary of the Society, and such request shall state the purpose or purposes of the proposed meeting. Business transacted at any special meeting of members shall be limited to the purposes stated in the notice. Written notice stating the place, day, and hour of the meeting and, in case of a special meeting, the purpose or purposes for which the meeting is called, shall be delivered not less than ten (10) days nor more than fifty (50) days before the date of the meeting, either personally or by mail, by or at the direction of the president, the secretary, or the officer or person calling the meeting, to each member entitled to vote at such meeting. Members holding one-tenth of the votes entitled to be cast, represented in person or by proxy, shall constitute a quorum at all meetings of the members. When a quorum is present at any meeting, the vote of a majority entitled to vote, present in person or represented by proxy, shall decide any questions brought before such meeting, unless the question is one upon which by express provision of the statutes or of the Articles of Incorporation a different vote is required, in which case such express provision shall govern and control the decision of such question.

SECTION 5. Whenever any notice is required to be given under the provisions of the statutes or of the Articles of Incorporation or of these by-laws, a waiver thereof in writing signed by the person or persons entitled to such notice, whether before or after the time stated therein, shall be equivalent to the giving of such notice. Any such signed waiver of notice, or a signed copy thereof, shall be placed in the minutes of the corporation.

ARTICLE X. AMENDMENTS

Amendments to the by-laws may be proposed by a resolution of the executive committee, or in writing by ten per cent of the members of the Society. All such resolutions or proposals must be submitted at the annual meeting of the Society as provided in the by-laws. If such recommendations shall be favorably acted on at the annual Society business meeting, the secretary shall arrange for a ballot of the members by mail within sixty (60) days after said annual Society business meeting, and a majority vote of the ballots received within sixty (60) days of their mailing shall be sufficient to amend. The legality of all amendments shall be determined by the executive committee prior to balloting.

ARTICLE XI. DUES

SECTION 1. The fiscal year of the Society shall correspond with the calendar year.

SECTION 2. The annual dues of members shall be twenty-five ($25.00) dollars. The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member before December 1 of each year, stating the amount of the annual dues and penalty and conditions for default in payment. Members who fail to pay their annual dues by January 1 shall not receive copies of the Society's publications until such arrears are met.

The executive committee may at its discretion suspend or waive annual dues to members serving in the armed forces of the United States, or any allied country, without otherwise affecting their status in the Society.

ARTICLE XII. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member may resign from the Society at any time. Such resignation shall be in writing and shall be accepted by the executive committee.

SECTION 2. Any member who is more than a year in arrears in payment of dues shall be suspended from the Society.

SECTION 3. Any member who resigns, is dropped, or is expelled, under the provision of this article, ceases to have any rights in the Society, and ceases to incur further indebtedness to the Society.

SECTION 4. Any person who has ceased to be a member, under Section 1 or Section 2 of this article, may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and/or other indebtedness to the Society on the date when he ceased to be a member.

SECTION 5. Charges of misconduct in violation of Article VI or the Principles of Acceptable Evaluation Engineering Practice hereof shall first be submitted in
writing to the president of the Society by a member in good standing, with a full statement of the evidence on which the charges are based. If, in the judgment of the president such charges merit further consideration, he shall appoint a grievance committee which shall examine them. If, in the judgment of this committee, the facts warrant, formal charges against the accused member shall be prepared and filed with the executive committee. After the receipt of such formal charges, the executive committee shall fix a date and place for hearing thereon, and shall give to the accused person notice thereof in writing, sent by registered mail to his last known address not less than thirty (30) days before said date, accompanied by a copy of the formal charges and a copy of this article.

Section 6. On the day fixed for the hearing, the accused person may appear or be represented by counsel of his choice before the executive committee, hear any witness called in support of the charges and, at his option, cross-examine the same, present witnesses of his own, and submit oral or written statements in his own behalf. The executive committee may likewise present witnesses and have the right of cross-examination. At his option, the accused may by registered mail to the president at the Society headquarters, postmarked not less than ten (10) days prior to the date of the hearing, waive personal appearance and request the executive committee to adjudge the matter on the basis of a written statement of his defense accompanying such letter. After the conclusion of the hearing or the study of the written defense submitted in lieu thereof, the executive committee shall consider and vote to sustain or dismiss the charges. If the executive committee shall, by unanimous vote, declare the charges sustained, it may suspend the accused person for a stated period of time, admonish him, allow him to resign, or expel him. Failure of the accused person to appear, or to submit a waiver letter and a written defense as in this section provided, shall not prevent the executive committee from rendering final judgment and taking action on the basis of the evidence available on the hearing date. The attendance of the president and at least two other members of the executive committee shall constitute a quorum and full representation of the committee for the conduct of the hearing provided in this section.

Section 7. Resignation of the accused person from the Society at any stage of the foregoing prescribed proceedings, shall automatically terminate the proceedings.

Section 8. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of Section 5 and 6 of this article shall be final.

Principles of Acceptable Evaluation Engineering Practice

Article I. General Practice

1. In preparing an evaluation, the member will arrive at an answer which is no more and no less than the facts indicate.

2. The answer will neither be a conservative nor an optimistic one.

3. The report must describe how the answers were calculated, unless the report in this form is not requested by a client and a statement to this effect shall be a part of the report. Work sheets must be retained for three years showing all pertinent calculations.

4. In case of evaluation of a property or properties for sale or financing purposes, the report must show the estimated net cash flow before income taxes, resulting from the production of the proved reserves from such property or properties discounted at a stated rate of annual interest. If the result in other terms is requested by the client, the report should so state. The report should also state whether a field inspection and/or well tests have been made.

5. The Society has adopted and shall adhere to the following:

Definitions of Proved Reserves for Property Evaluation

Proved Reserves—The quantities of crude oil, natural gas and natural gas liquids which geological and engineering data demonstrate with reasonable certainty to be recoverable in the future from known oil and gas reservoirs under existing economic and operating conditions. They represent strictly technical judgments, and are not knowingly influenced by attitudes of conservatism or optimism.

Undrilled Acreage—Both drilled and undrilled acreage of proved reservoirs are considered in the estimates of the proved reserves. The proved reserves of the undrilled acreage are limited to those drilling units immediately adjacent to the developed areas, which are virtually certain of productive development, except where the geological information on the producing formations insures continuity across other undrilled acreage.

Fluid Injection—Additional reserves to be obtained through the application of fluid injection or other improved recovery techniques for supplementing the natural forces and mechanisms of primary recovery are included as "proved" only after testing by a pilot project or after the operation of an installed program has confirmed that increased recovery will be achieved.

When evaluating an individual property in an existing oil or gas field, the proved reserves within the framework of the above definition are those quantities indicated to be recoverable commercially from the subject property at current prices and costs, under existing regulatory practices, and with conventional methods and equipment. Depending on their development or producing status, these proved reserves are further subdivided into:

1. Proved Developed Reserves—Proved reserves to be recovered through existing wells and with existing facilities:
   a. Proved Developed Producing Reserves—Proved developed reserves to be produced from completion interval(s) open to production in existing wells;
b. Proved Developed Nonproducing Reserves—
- Proved developed reserves behind the casing of existing wells or at minor depths below the present bottom of such wells which are expected to be produced through these wells in the predictable future. The development cost of such reserves should be relatively small compared to the cost of a new well.
- Proved Undeveloped Reserves—Proved reserves to be recovered from new wells on undeveloped acreage or from existing wells requiring a relatively major expenditure for recompletion or new facilities for fluid injection.

6. If the member preparing the report has a vested interest in the properties being evaluated, he should so state.

7. There shall be a member seal of the Society and members may purchase and affix this seal to their letters and reports.

ARTICLE II. RELATION OF MEMBERS TO THE PUBLIC

1. A member will avoid and discourage sensational, exaggerated, and unwarranted statements with regard to professional matters that might induce participation in unsound enterprises.

2. A member will not knowingly permit the publication of his reports or maps for any unsound or illegitimate undertaking.

3. A member will not give a professional opinion, make a report, or give legal testimony without being as thoroughly informed as might reasonably be expected considering the purpose for which the opinion, report, or testimony is desired; and the degree of completeness of information upon which it is based should be made as clear as possible, in the opinion, report, or testimony.

4. A member may publish dignified business, professional, or announcement cards, but shall not advertise his work or accomplishments in a self-laudatory or unduly conspicuous manner.

5. A member shall not issue a false statement nor give false information even though directed to do so by employer or client.

ARTICLE III. RELATION OF MEMBERS TO EMPLOYER AND CLIENT

1. A member shall protect, to the fullest extent possible, the interest of his employer or client so far as is consistent with the laws of the state, the public welfare, and his professional obligations and ethics.

2. A member will not use, directly or indirectly, any employer’s or client’s confidential information in any way which is competitive, adverse, or detrimental to the interest of employer or client.

3. A member retained by one client will not accept, without the client’s consent, an engagement by another if the interest of the two are in any manner conflicting.

4. A member who has made an investigation for any employer or client will not seek to profit economically from the information gained, unless permission to do so is granted, or until it is clear that there can no longer be conflict of interest with original employer or client.

5. A member will not divulge information given him in confidence.

6. A member will engage, or advise his employer or client to engage, and cooperate with other experts and specialists whenever the employer’s or client’s interests would be best served by so doing.

7. A member shall not accept a concealed fee for referring a client or employer to a specialist or for recommending petroleum evaluation services other than his own.

ARTICLE IV. RELATION OF MEMBERS TO EACH OTHER

1. A member will not falsely or maliciously attempt to injure the reputation or business of another person.

2. A member will freely give credit for work done by others, will refrain from plagiarism in oral and written communications, and will not knowingly accept credit rightfully due another person.

3. A member will not use the advantages of salaried employment to compete unfairly with another member of his profession.

4. A member will endeavor to cooperate with others in the profession and will encourage the ethical dissemination of petroleum evaluation knowledge.

5. A member will immediately notify another member who may knowingly or unknowingly be practicing unethically or making misleading reports, and, failing to obtain a satisfactory explanation and amends within thirty (30) days shall report such practices or reports to the president of this Society for proper action.

ARTICLE V. DUTY TO THE SOCIETY

1. A member of the Society will aid in preventing the election of a member who does not abide by the Canons of Ethics and these Principles of Acceptable Evaluation Engineering Practice or who does not have the required education and experience.

2. It shall be the duty and professional responsibility of a member to uphold the Canons of Ethics for Engineers and the Principles of Acceptable Evaluation Engineering Practice of the Society by precept and by example. Where necessary, he shall encourage by counsel and advice to other members adherence to the Canons and Principles.

3. In making application to become a member or continuing as a member in the Society, a member agrees to uphold the Canons of Ethics, and Principles of Acceptable Evaluation Engineering Practice as herein established.
MEMBERS
OF
THE SOCIETY OF PETROLEUM EVALUATION ENGINEERS

Mobile, Alabama
Petrouston, Peter C.

Calgary, Alberta
Lowe, Howard R.

Los Angeles, California
Lewis, Milton W.
O'Brien, Jerome J.

South Pasadena, California
van Wingen, N.

Denver, Colorado
Ferry, John Huntington

Chicago, Illinois
Burnett, Peter G.

Wichita, Kansas
Fair, F. Doyle

Lafayette, Louisiana
Bates, Fred W.
Elshury, Lee W., Jr.

New Orleans, Louisiana
Bowling, Leslie
Meltzer, Lee Hillard
Miller, John Cummins
Simmons, Fred E., Jr.
Willits, Myron H.

Shreveport, Louisiana
McGuire, T. W.

Kansas City, Missouri
Hall, A. L.

Omaha, Nebraska
Grimm, Richard Dean

Jackson, Mississippi
Mayer, Harold R.

New York City, New York
Deadman, Harry L.
Olansen, Norman A.
Sherrod, Gerald E.
Stewart, Fraizer M.

Tulsa, Oklahoma
Earlougher, R. Charles

Ford, William T.
Hover, Thomas C.
Keplinger, Charles H.
Kornfeld, Joseph A.
Kravis, Raymond F.
Southmayd, William Clark
Wanemanncher, J. M.

Abilene, Texas
Anders, E. L., Jr.

Big Spring, Texas
Penner, Robert Francis

Corpus Christi, Texas
Beaver, M. H.
Fly, Jack Paul
Prueitt, Hornton T.

Dallas, Texas
Arps, J. J.
Bednar, W. C.
Brack, John Raymond
Calhoun, Tom Gilmer, II
Clark, Norman J.
Crichton, Jack A.
Fagin, Kyle Marshall
Franklin, Robert Odell, Jr.
Garb, Forrest Allan
Gruy, H. J.
Jeffrey, Thomas J.
Lamoreaux, William E., Jr.
McCord, David R.
Oliver, Fred L.
Ritts, Howard J., Jr.
Schafer, Jack D.
Smith, Aurel E.
Vaughan, Joe E.

El Paso, Texas
Derrick, A. M., Jr.

Fort Worth, Texas
Atkinson, Burton
Keller, Wallace P.
Petersen, L. F.

Houston, Texas
Bertch, Thomas M.

Brinkerhoff, Ira*
Brown, Charles W.
Brown, W. Emmett
Cantrell, C. D., Jr.
Clark, J. Donald
Colle, Jack
Crego, William O.
Daniels, E. Ralph
Grandall, Kenneth G.
Harding, Henry Wildy
Hall, Donald L.
Hughes, James Douglas
Hurst, William
Jensen, Walter P., Jr.
Laird, Joe A.
Mefford, Nace F., Jr.
Moredock, S. Kenneth, Jr.
McGonagill, Frank E., Jr.
Newton, Paul Francis
Parkans, Sidney A.
Poyner, Herbert F., Jr.
Pressler, Edward Doerk
Sims, Henry L.
Stovall, George Alston
Taylor, George W.
Vance, Harold
Watson, Joseph P., Jr.

Midland, Texas
Moore, J. Hiram
Phillips, Charles E.

Odessa, Texas
Jarrell, Malcolm

San Antonio, Texas
Schutz, Charles D.
Spire, William H., Jr.

Victoria, Texas
Hamel, Roger C., Jr.
Weatherly, Justin Eugene, Jr.

Wolfe City, Texas
Nichols, Earl A.

Washington, D. C.
Albaras, Edward A.
Hamilton, C. E. (Mike)

*Deceased

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PAPERS PRESENTED BEFORE
THE SOCIETY OF PETROLEUM EVALUATION ENGINEERS

1963 First Annual Meeting, Statler Hilton Hotel, Dallas, Texas, November 15, 1963
Brief Introductory Discussion by Mr. Harold Vance,* Houston, Texas
Definition of Evaluation Terms, by Mr. J. J. Arps,* Dallas, Texas

1964 Second Annual Meeting, Dallas Petroleum Club, November 16, 1964
No paper given, but a discussion entered upon of the general policies of the SPEE

1965 Third Annual Meeting, Hotel America, Houston, Texas, December 3, 1965
Panel: What the Banks, Insurance Companies and Investors Expect in Evaluation Reports.
Mr. Eddie Montieth, Executive Vice President, Republic National Bank, Dallas, Texas
Mr. Gerald B. Haecelk, Vice President, New York Life Insurance Company
Mr. Jeff Montgomery, President, Kirby Petroleum Company, Houston, Texas
Steam Floodin Results by Mr. Henry Kep-linger,* Tulsa, Oklahoma
Outlook for Oil Industry for Next Five Years by Mr. Harold Vance,* Houston, Texas
Panel: How Evaluation Engineers Can Best Work With Attorneys and Accountants
Mr. Ben Rice, Attorney, Vinson, Elkins, Weens and Searls, Houston, Texas
Mr. Pete Wehner, Accountant, Arthur Andersen & Co., Houston, Texas
December 2, 1965 SPEE Luncheon, Houston, Texas
A Broker's Observations of Oil & Gas Property Acquisitions, by Paul F. Newton,* Houston, Texas

Panel: Discussion on Financing of Oil & Gas Property Purchases
Mr. Ken Boren, Vice President, Republic National Bank, Dallas, Texas

Mr. H. M. Meredith, Vice President, First National Bank, Dallas, Texas
The Impact of Nuclear Energy on our Domestic Economy by Mr. Davis G. Hawthorn, Houston, Texas
Accuracy of Reserve Estimates and Definitions of Proved Reserves by Mr. J. J. Arps,* Dallas, Texas

1967 Fifth Annual Meeting, The Hilton Inn, Dallas, Texas, December 7 and 8, 1967
A Statistical Study of Recovery Efficiency, by Mr. J. J. Arps,* Prof. Folker Brons, Messrs.
A. F. van Everdinger, R. W. Buchwald, and A. E. Smith*
Proration Effects on Evaluation by Granville Dutton. Proration Engineer and Attorney, Sun Oil Company, Dallas, Texas
General Panel Discussion by Tom G. Calhoun, II,* J. J. Arps,* Fred L. Oliver,* and Norman J. Clark*
(1) Reserve Determinations for Company Annual Reports
(2) What is Conservation
(3) Communication Problems Between Consultants, Clients, and Financial Institutions
Our Future Gas Supply by J. M. Wanenmacher,* Tulsa, Oklahoma

1968 Sixth Annual Meeting, Warwick Hotel, Houston, Texas, November 17 & 18, 1968
Banking and the Petroleum Industry by Harold Vance*
Handling of Disclosure as to the Reserves for the SEC, by Ted T. White

*Member of SPEE
Members of the SPEE

Gentlemen:

As the present editor of the Journal of the Society of Petroleum Evaluation Engineers, and the first to hold this position, I would like to make the following comments:

That this Journal was overdue, as set up in the By-Laws of the SPEE, there is no gainsay for the purpose of its existence. In my belief it is an important adjudant to our Society.

As indicated in this first issue, considerable weight is given to the economics of oil and gas properties evaluation. This is part of it, since reserves are involved, necessarily it follows that reservoir engineering in evaluating reservoirs must also be considered, but to a lesser degree, which is represented by a paper in this first issue treating with the subject.

To conclude, it is the wish of the Editor of the Journal of the Society of Petroleum Evaluation Engineers, that this Journal become one of the foremost publications to present the worthwhile papers in the future. It has this potentiality.

Very truly yours,

William Hurst
Editor of the Journal of the Society of Petroleum Evaluation Engineers

WH:jag
Commercial banks, as we understand them, did not come into being until the 16th century, A.D.

Two thousand years before the birth of Christ, the ancient Babylonians were using deeds, leases of land, wills, accounts, notes, mortgages and receipts for storage. These were engraved in clay tablets, which were then baked until hard.

Interest was set at twenty per cent for loans of money (measured weights of silver or gold). At this time wages for skilled workmen were equivalent to about thirty-five cents a month, based on wheat that sold for seven cents a bushel.

There were no banks in the strict sense of the word, but certain powerful families carried on the business of lending money. Loans were made on signatures, property and crops, which were mortgaged to insure repayment.

A great step forward in banking was made (570-546 B.C.) by issuing gold and silver coins, minted and guaranteed at their face value by the state.

Paper was invented in China about 105 A.D., which made possible the issuance of paper money, certificates of deposit, bills of exchange and simplified records of all kinds that could be easily stored and transported.

Our modern safe deposit facilities originated in Greece. The only safe repository for valuables was the Temple, and regular and substantial charges were made for this service. In a limited sense, the priests soon became bankers, because they were lending their own funds at interest.

Interest remained illegal in Rome for more than 250 years, having been forbidden by an edict issued in 342 B.C. But, enforcement of such legislation was impossible. In 88 B.C. interest was legally fixed at one per cent per month and in 50 B.C. this rate was made standard throughout the Roman Empire. This rate was a far cry from the twenty, thirty and even fifty per cent rates prevalent before that time.

Finance collapsed completely with the end of the Roman Empire, and throughout the Dark Ages banking lay under an eclipse. Letters of credit (drafts) were used during the early twelfth century Crusades, and money lending was common.

Italy is the mother of western banking as it is practiced today. Banking fell largely into the hands of private families; as early as the fourteenth century, the Bardi family of Florence had established agencies as far north as England and Germany.

Following the discovery of America, the flow of precious metals from this new land to Europe in the sixteenth century soon became five times the total output of the Old World. Most of this bullion found its way to northern and western Europe, where it was to give huge impetus to the growth of the industry.

But in the cities of South Germany, a new group of financiers rose swiftly to power. Firms like the Fuggers and Welsers established branches in Spain and bought the whole of incoming bullion fleets from the government at a huge discount, months before they arrived. The wealth accrued from banking activities enabled such men to purchase huge interests in industrial, trading and mining enterprises, and to run their affairs on a grand scale, unprecedented in history. Thus did America, through her gold, give extension to private enterprise while she was yet struggling in the earliest stages of colonization. And private enterprise was the economic way of life that was eventually to make a part of America, the United States, by far the wealthiest and most powerful of the earth's nations.

The Rothschild family, for 150 years, has been a good example of a family bank. Members of this family still are carrying on private banking business here and in Europe. It is reported that Nathan Rothschild, a member of the family banking corporation, was once asked, "What is the secret of your financial success?" He is reported to have replied, shaking his head sadly, "Oh, I always sold too soon."

The Bank of North America, organized under the leadership of Robert Morris, began business in Philadelphia on January 7, 1782, and this bank, together with the Bank of Massachusetts and the Bank of New York, both of which were founded in 1784, marked the real beginning of American banking.

After two tries at a U.S. Government bank, the first in 1791 and the second in 1816, banking conditions fell to a low level. Hundreds of state banks came into being, and during the period 1840-1843, one-fifth of the banks failed.

The National Banking Act was passed on June 3, 1864, with three main objectives:
1. To obtain uniform currency
2. To provide a market for government bonds
3. To improve banking conditions

This Act required banks to keep specified reserves which were principally backed by merchandise instead of adequate reserves; and this requirement probably helped bring on the panic of 1907, which resulted in the Federal Reserve Act on December 23, 1913.

This law permits member banks to borrow from the Federal Reserve, at a discount rate, which can be changed by the Federal Reserve at any time.

The national banks increased rapidly with a corre-
sponding decrease in state banks. However, since the national banks could not lend money on real estate or engage in trust activities and more capital was needed to incorporate, the number of state banks started to increase. By 1914, there were 14,512 state banks and only 7,495 national banks; but, the national banks held about 75% of all banking resources.

The federal bank examiners make an examination of each national bank. If the examiners think any loan will be a loss in whole or in part, the bank will be required to write off all or part of this loan against its “reserve for loan losses.” This action means the examiners do not consider the loan an asset of the bank.

The foregoing is a brief history of the banking industry and how essential banks are to industry; however, before the advent of banks in Alaska, the liberal credit policy of the Northern Commercial Company (which was really a series of trading posts) provided the North’s banking system. Valuables could be left at any company store for safekeeping. Miners could pour their dust down the funnel of the gold scales at Company stores and “cash out” without waiting seven months to a year for outside banks or the mint to remit. Customers could obtain drafts or request checks written either for their personal use or made out to other creditors for them by Northern Commercial Company.

**The Oil Loan**

The bankers were slow to consider recoverable oil and gas in the ground as satisfactory security for a loan. An acquaintance of mine recently told me that his father had always told him to confine his business to things he could see, such as trees and solid minerals, which could be exposed to view. This is the reason he never got into the oil and gas business. However, he finally found himself the Chairman of the Board of a small royalty company because someone found and produced oil and gas from free lands owned by the corporation.

Mr. John D. Rockefeller, Sr. has been quoted as saying that he did not want anything to do with the production phase of the oil business because it was too risky. But, he felt there were plenty of people who would take the risk and provide him with sufficient crude to run through his refinery. He built an empire following this philosophy.

The only reason in the world that a fully integrated company should own any production of its own would be as a protection to its other investments in gathering systems, refineries, wholesale and retail outlets.

Years ago, I felt that by this time, all of the major companies would have divested themselves of their own production, retaining the right to purchase the oil from these properties for the life of the reserve. This, of course, has not happened, and we begin to wonder why, since a small independent operator can produce crude so much cheaper than a major company. The depletion allowance could well be a reason the majors have continued as producers.

As you know, for several years, the folks who have need for crude, the fully integrated companies, have set up acquisition departments and they have acquired a number of producing properties.

However, more recently, one of the majors changed, seemingly overnight, to a program of disposing of certain of its own producing properties. In some instances the properties disposed of were isolated properties which were costing too much to operate. I understand that this change came about because the company had been convinced that it could find producing properties cheaper than it could buy them. This is a complete reversal of the general thinking that prevailed a few years ago.

Other companies have also been selling their properties, especially those which have no reserves. No deep rights were transferred to the purchaser under these integrated company sales of production.

There has also been a sale of some properties in which all deep rights were conveyed to the purchaser, and the selling company did not reserve the right to purchase oil which might be produced later from the deeper formations. I know of one instance of this kind, and there may have been some circumstances which influenced the integrated company to dispose of these deep rights.

In some of the boom fields, new refineries, within or adjacent to the field, were a part of the boom era. As production declined, these refineries were abandoned due to lack of sufficient production to operate economically.

The East Texas Field was probably the last boom field in which there was also a boom in local refinery construction and operation.

The fully integrated companies have various means of acquiring capital which are not available to the small independent operator. Most of these companies grew out of the efforts of an individual who finally combined what he had with others, formed a corporation, thereby acquiring sources of capital not available to him as an individual. We still have a few of these individuals who are well known to all of us, who continue to operate as an individual; but, most of them have acquired so many assets they represent a good lending risk to a bank and to other lending institutions.

In order to better understand how several independents may acquire the status and enjoy the credit advantages of integrated companies, the following example is presented:

Messrs. Anders, Boyd, Carter and Dean are independent operators; each own interests in oil and gas properties and they have decided to form a corporation and assign all their interests to the corporation. The name “ABCD Oil Company” was selected and the amount of stock was two million shares, with one million shares to be exchanged for the properties of the four individuals. They selected a petroleum evaluation engineer to determine the present value of each property, and a certified public accountant to determine the cash portion, total assets and liabilities for each of the four in the corporation. The number of shares of stock each received for his property will be
determined by this information.

Thus, each of the former independent operators now own stock in a corporation which in turn owns the property they owned separately.

Each of the four corporation owners will be a member of the Board of Directors which in turn will elect the following officers: President, Vice President, Secretary and Treasurer. These operating officers will manage and determine the company policies.

The corporation could sell some of the second million shares, but this would reduce the equity of the original incorporators.

It is decided to make an oil loan with an oil bank, which would put its own value on the properties and may lend up to 1/2 of present value of the properties. The company may not need all of this money at one time: so a master note is signed for the total amount which could be loaned, and the money drawn out as needed. Monthly payments plus interest would probably be required by the bank. The Corporation would give the bank a mortgage on all its properties, and the bank would probably require that the mortgage be applicable to all properties acquired after the signing of this mortgage. The bank may even require all four of the original incorporators to sign the note personally.

The financial arrangement made with the bank is ideal until the corporation reaches the point where it does not have sufficient security or present income to satisfy the bank for additional loans against the company properties. In other words, the corporation may find itself completely "loaned up" with the bank.

The four original stockholders are concerned about maintaining their present equity position in the corporation; so they decide not to sell any of the stock to others. Instead, they decide to sell interest bearing convertible subordinated debentures to private or institutional investors, if possible, otherwise, to the public, and use the money derived from this sale to pay off the bank and secure a release of the mortgage. These interest bearing convertible subordinated debentures are in effect an unsecured loan to the corporation, which may be converted into stock within a certain time limit at a stated price per share.

The corporation has thus exchanged a mortgage loan for an unsecured loan. It is now in the position to, and does, go back to the bank and sign a new mortgage on the property, also a new note, making it possible to borrow from the bank as it did in the first instance. This procedure can, and is, often repeated several times.

Eventually, it may be desirable to sell some capital stock as a means of providing more capital and to increase the number of stockholders. State and federal regulations must be complied with in order to provide funds for growing corporations as outlined above.

In my experience in oil banking, I found a number of our customers would get themselves into financial difficulty by drilling too many wells and drilling them too fast. I remember telling some of these fellows that they were working too hard at their business and they ought to take a six-month vacation to let their income reduce their debt, and incur no liabilities during this six-month period. Along the same lines, I want to quote part of an article in the U. S. News and World Report, May 27, 1967 issue:

"U.S.: 'Riches to Rags in 20 years'... How did the U.S. manage to slip from the pinnacle it occupied at one time to its present position? How did it dissipate not only a great lead in material wealth and financial stability...?"

The answer, in its simplest form, given by bankers and economists: "By trying to do too much, too fast."

I was interested to find that most of the borrowers with whom I dealt during my 12 years in an oil bank thought they were never going to die, and if they did die, they were going to be able to take their wealth with them!

Interest

Interest has been defined as the rent paid for the use of borrowed money. The lender, within a stated time, expects to receive all of his money back, plus interest.

Interest was legalized in France and England after the discovery of America.

The tremendous need for borrowed money in the petroleum business is illustrated by the records of forty-five representative American oil companies which show an indebtedness of almost $13 billion in 1967, and some $620 million were paid by these companies in interest for the use of this money. The total sales of these companies during 1967 was $84 billion. These companies had 800,000 employees and 3,000,000 stockholders.

Interest is a legitimate operating expense, just as rented equipment or office space are legitimate business expenses.

A modern bank, in some ways, is like a warehouse combined with a rental agency: It is a safe depository for your own money; it has additional money which you may rent, if you can satisfy the bank that you can pay back the principal plus interest; you can use this borrowed money for whatever needs your business demands.

A bank borrows money to carry on its business. In 1967, 38 representative banks in the United States had borrowed some $1400 million and paid $62.5 million for the use of this money. These same banks had 227,000 employees and 863,000 stockholders.
WHAT MAKES THOSE BANK ENGINEERS SO CONSERVATIVE?

By Gerald E. Sherrod, Vice President, First National City Bank, New York, N. Y.

Presented at the Sixth Annual Meeting of
The Society of Petroleum Evaluation Engineers
Warwick Hotel
Houston, Texas
November 17-18, 1968

My purpose here is to explain the position and viewpoint of the oil lenders and to tell you the broad basis on which Citibank makes oil and gas loans. My remarks will be directed principally towards the non-recourse, ABC type oil loan. When I refer to oil loans I am including gas, distillates, and plant products.

What makes those bank engineers so conservative?

How many times have we all heard that query?

Let me quote from Shakespeare’s Hamlet: “Neither a borrower nor a lender be; for loan oft loses both itself and friend”.

The economy of our country would still be back in the colonial stage if this quotation had been adhered to by our ancestors.

Let me rephrase the quotation in what I believe should be the modern version: “Neither an unsafe borrower nor an unsafe lender be; for an unsafe loan oft loses both itself and friend”.

Banks are service oriented organizations and when we try to meet a customer's loan request our problem is fairly simple in concept. We must design an oil loan that will permit the customer to accomplish his purpose, profitably, and we must make sure that the loan is a safe loan for the bank.

This can be a delicate position to be in. In acquisition financing if the loan size is too small the customer may not be able to make his purchase in a competitive situation. If the loan is too large the bank may lose money. If, to accommodate a customer, a bank makes a loan that is too large, this may make the customer happy initially but usually will make both the customer and the bank unhappy in the long run. Management of both the bank and the customer company always want to know how specific loans or purchases are performed compared to their forecast. If a loan (and purchase) gets very far behind the original forecast it becomes a matter of embarrassment to the banker and the customer. When this happens the customer is usually more comfortable doing his banking business where the atmosphere is less embarrassing. In other words, a bank cannot always win doing what the customer desires.

Do banks take risks on oil loans? Not intentionally, but unfortunately the science of petroleum engineering and the Banker’s financial analysis of companies is not infallible. Even with the best of properties and a very accurate loan analysis there are factors beyond the control of either the lender or property operator that can cause slow loans or outright losses. Some of these factors are: drastic cuts in allowable, price cuts, loss of market, pipeline disconnection or even an unexpected water influx into a reservoir. Thus far, however, the loss ratio on oil and gas loans has been low at our Bank and other oil banks, and these loans are still attractive to lenders. We ran a survey of 40 oil lenders which showed that about 5% of all types of loans made, based on production, became problem loans. About 1.7% of these loans involved losses but the actual loss experience was less than 0.4% of the original face amounts extended.

One myth that has persisted over the years is “why should the banker care if the loan repayment is slower than forecast, he is getting his interest isn't he?” Well, to a banker TIME IS MONEY AND MONEY IS TIME. Banks are service organizations and, therefore, the more times the same money can be loaned out the more service banks can offer to their customers. Although some insurance companies are amenable to having well secured oil loans stretched out, with the final loan term extended well beyond the original term, nothing pleases banks more than to have loans pay out right on schedule.

This brings me to the subject of the types of risks that lenders are subject to on oil loans.

There are two types of risk; the first is called the loss risk, that is, will the lender lose all or part of his investment? When a situation develops where it is indicated that an oil loan is likely to result in a loss, the lender has only a few choices of action:

With the cooperation of the present owner the lender may seek a buyer for the property, or he may foreclose on the interest under mortgage. If it is a production loan he can foreclose on the entire property but if it is a payment loan he can foreclose only on that portion of the production pledged to the loan. A production payment is a non-operating interest in oil and gas which can be retired only from production when, as and if it is produced. In either case he can:

a. Leave the existing loan on the property, or
b. Sell the loan at a discount and take a loss.

If it is a production loan he can take over the operation of the property; in a payment loan the lender may succeed to the operation if the present operator abandons the responsibility or voluntarily turns the operations to the lender.

Foreclosure is the step that the lender is most reluctant to take. If the situation is bad enough to foreclose on, it probably means an immediate loss on the loan, while by riding it out there is always the hope that the loss will be reduced or that most of the investment will be recovered. Certainly foreclosure is bad public relations. Operation of a property is also un-
attractive to lenders because it is costly, time consuming and inconvenient.

The second type of risk is called the term risk, that is, will the loan be repaid on schedule so that the money can be used again as scheduled? You are familiar with situations where investments get tied up for periods far exceeding the original expectation. Disregarding the liquidation possibility, the best solution may be the passage of time with the investor hoping the situation will work itself out. This is analogous to the situation on oil property loans where something interferes with the production with the result that the loan amortization is extended far beyond the original forecast. If the reserves are adequate there is usually no loss; however, if the term is extended too far it can lead to a loss even with excellent reserves. Loans with terms in excess of 10 years are more vulnerable because of the relatively small proportion of loan service that is applied to principal in the early years. If the property revenue flow is forecasted to increase substantially from further drilling, allowable increases, secondary recovery response, etc., the term risk and loss risk liability are increased sharply if the revenue increases do not take place.

Let me review the chief difference between the investment position of a customer and a bank lender. The customer is usually an oil company who has the normal profit incentive. He is used to taking risks because he deals in one of the more hazardous investment media. However, in his risk oriented investment atmosphere he usually judges his potential profit, or loss, on his equity investment. He invests large sums of money on acreage, exploration, drilling and development of property without complete assurance of getting his investment back on any one project. In fact, a considerable passage of time, after investment, is usually necessary before he can ascertain that he will get his money back or that he will make a profit. How does he circumvent the risk on individual prospects? First he uses every available analysis tool and second he spreads his risk among many projects. How can he do so well in face of these risk obstacles? He has one advantage that the bankers do not have, he can apply profits from successful projects against unsuccessful ones when calculating overall return on risk assets or investments. On the other hand: The bank lender is using depositories money which, collectively, must be returned to them at some future time. In other words, the depositor's money cannot be put at risk. The company, however, is using equity investor's money which can seek a high yield return on risk assets and he does not have to return the investor's money upon demand.

The viewpoint of the bank lender is geared to the fact that the most he can ever get back from a loan is the principal and interest, nothing more and he hopes, nothing less.

In most property purchases the buyer can look forward to getting his equity investment returned several times over prior to abandonment of the property. In any case his average rate of return is well in excess of the interest rates that are charged on oil loans. The customer also can benefit from plus factors such as unexpected discoveries on undrilled acreage acquired and unexpected reserves from secondary or tertiary recovery mechanisms. The lender, however, can only collect his profit from interest, and therefore, has a very narrow margin from which to create a profit pool against which he can charge any substantial losses. The customer (on the other hand) with his larger profit potential, can create profits which he can use to offset periodic equity losses. This provides a base on which he can take some risk.

Citibank uses a lending base which we believe has minimized our risks and has satisfied our customers' goals.

When appraising properties for loans we place the most importance on the following three factors:

1. Quality of reserves
2. Management—Operation
3. Spread of reserves

My comments will assume that adequate data is available and that a thorough engineering appraisal has been made on the properties in any specific loan situation.

In reserve analysis the determination of the quality and quantity of the reserves is related to the age of the field. The ideal reserve, of course, is in a field which has a high reserve to production ratio and which can be produced at a low cost. The best reserve estimates are based on reservoir performance and most engineers feel that more accurate estimates can be made when at least 20% (some prefer 40%) of the ultimate recoverable reserves have been produced at the time of the appraisal.

Examples of high quality fields are East Texas, Sacroc and Wilmington; these fields have massive oil columns and long production histories. Reserve estimates and production rates can be estimated accurately within plus or minus 5% in these fields. Their operating, work-over and maintenance costs are well established; their future investment requirements are predictable.

The area of maximum risk in estimating primary reserves is the new field which has been partially developed but lacks sufficient performance history on which to judge the volumetric reserves estimates. There are such situations in which the productive zones are so large or multitudinous that there is little doubt that very large reserves are present, underground, on the property. However, usually at this stage of partial development, the reservoir limits have not been firmly defined: such parameters as water levels and porosity pinchouts are estimated from a limited geological interpretation. Besides the potential errors in estimating reservoir volumes there is usually very little performance history on which to base the recovery efficiency. In other words, there is not only a possible error in how much oil is in place but also in how much of it can be recovered. If the reservoir analysis in this case
is essentially volumetric, with little performance, the reserve error can be in the area of 50% plus or minus.

In older fields where only 25% or less of the ultimate reserves remain, the magnitude of reserve error is probably less than 10%. However, from a lender's standpoint, the amount of revenue available for loan service may be small in relation to the reserves because of the high cost of operation during the latter stages of depletion.

It is usually difficult to determine the quality, or loan value, of those reserves which are not primary reserves. We are frequently asked to make loans on reserves which can be broadly classified as undrilled reserves and non-producing reserves. The non-producing reserves are usually either behind-the-pipe or in proposed secondary recovery programs. Many times these reserves are termed probable, possible, potential or additional reserves.

The undrilled reserves can vary from infill locations to situations where only one well has been drilled and the rest of the reserves claimed for the field are based wholly on geological interpretation. The danger, of course, in undrilled reserves is: first, the possibility of drilling a dry hole, second, the risk that offset operators will drain all or part of the reserves off the property and, third, the risk that the present operator may not have sufficient capital to drill all the proposed locations. Behind-the-pipe reserves are also subjected to the latter two hazards.

The secondary recovery reserves can vary from projects that have been completely developed and are over their peak to situations where there has not even been a project tried in similar formations and the reserves should be more aptly described as a gleam in the operators eye. Of course, we view secondary projects that are fully developed and that are approaching their peak no differently (from a security standpoint) than from seasoned primary reserves.

If the property is still producing by primary and pilot floods have been successful on similar formations in the same area, the reserve risks on future secondary on this property are probably on the order of 50% plus or minus. If a property in the field has had a successful pilot flood on it, the reserve risk is reduced probably to 25% plus or minus. The problem from a lender's standpoint, in either situation, however, is that it is more difficult to forecast producing rates, operating costs and investment requirements in secondary recovery projects. Consequently, when we have to rely on net revenue for loan service there is considerably more room for error in the secondary projects, than in the primary in judging the amount of revenue available for loan service.

Gas or gas condensate reservoirs are usually viewed as better loan risks than oil reservoirs because of their higher reserve to production ratio, more stable market for the product, and the fact that their low-cost operation allows proportionately more revenue for loan service. Depressed gas prices, interrupted takes and pipe line proration have disturbed the normally serene gas market during the past 10 years.

MANAGEMENT-OPERATION

The second principal factor in our loan analysis is the management-operation of the properties.

In any property appraisal, it is usually assumed that competent management will be available to continue (or even improve) operations of the properties. When a well known company is the residual interest owner in a purchase, this problem is minimized. At the other extreme, there is the situation where the operator may be a one-man company with little or no technical ability and no other assets of any consequence except the properties under mortgage.

We cannot overemphasize the importance of good management on oil properties under loan. We ask ourselves a number of questions about the proposed management, some of which are:

Do they have adequate capital to run an enlarged operation? Are they adequately staffed with competent personnel in the areas of:

- Company administration—operations, finance, tax and accounting?
- Engineering/geology—at staff and field levels?
- Field operation—engineers, supervisors, pumpers, etc. . . . ? How well does their present geographical spread of personnel and facilities fit the new situation?

How good is their reputation? i.e., do they have a good reputation as administrators, as efficient operators, for staying up to date on technical advances and in all other phases of oil company operation.

If they have been involved in other loan purchases, we consider how well they have performed in them.

We are simply trying to determine whether or not they can adequately perform the management-operation function in an enlarged operation. Because of their profitability, at the field level, oil properties are considered excellent loan security, but as you all know, good management can decrease (or even ruin) the value of good oil properties.

SPREAD

The third principal factor in our engineering loan analysis is the distribution of reserves which, in turn, bears on the concentration of economic and political-regulatory risks.

A geographic spread of the reserves reduces the risk of reserve errors because many individual errors tend to compensate each other. If a field is a multi-pay producer then the one-field reserve risk is reduced considerably. This vertical spread protection does not, however, give adequate protection against the concentrated economic and political-regulatory risk. Horizontal reserve spread-protection may also be achieved in large units where the interest being appraised is undivided over a great many wells.

In the appraisal of proved undeveloped primary and secondary reserves, a large spread can offer substantial
protection in a situation where the number of properties involves a fairly large portion of reserves other than primary. These may be considered for loan analysis if the spread is adequate among the primary, secondary and undeveloped classes.

If the reserves are confined to one local geographic area, the economic risk is concentrated because of the vulnerability to price changes or interruption of the outlets in a one-field situation. Concentration also endangers the profit (or future net revenues) from the properties because the lifting costs are more vulnerable to local increases in labor costs and taxes.

The principal risk from a political standpoint is proration, either by the states or pipelines. Regulatory bodies can change gas/oil ratio penalties, spacing requirements, field rules and many other factors that, in one field, can influence the revenue stream severely. Properties hooked to one pipeline system (whether gas or oil) can have their outlet restricted or in some cases completely shut-in because of some economic factors that are beyond the control of the operator.

Pipeline purchasers have been known to levy gathering or pipeline transportation charges, which in effect reduce the posted price, thereby reducing the revenue available for loan service.

Perhaps I have overemphasized the spread factor in loan analysis. Certainly there is the danger that a loan appraiser will attach too much importance to spread and may neglect the quality and management aspects of a given situation. Too much spread, of course, can be inimical to loan security when the properties being considered are small splinter interests and are too widely spread. High administrative and overhead costs, on such properties, may prohibit their profitable operation and therefore endanger loan security.

GENERAL

In general our property appraisal approach for loan analysis is to seek an adequate balance between the factors of quality, management and spread. It is normally assumed that quality is the most essential factor. However, with a large enough spread on properties, in the medium-to-late depletion age, safe loans can be engineered on properties of lesser quality. If the quality is high enough, safe loans can also be made on properties where there is a one-field risk. Generally these situations must be properties where excellent performance has been demonstrated and long life reserves remain from which to service a loan. Adequate management must be available in every situation, but frequently this is automatic when competent management assumes control of properties upon purchase. Very few situations are found which have all these factors at the optimum: Quality and spread can compensate each other but nothing can replace competent management.

In conclusion, let me say that I believe that bank engineers have not been too conservative. Look at the record. In the last 15 years it is estimated that over 5 billion dollars of oil properties have been purchased which have been financed by banks and insurance companies. The number of loan losses and bad purchases has been small.

I believe we have accomplished our purpose. That is, the customers have made profitable purchases and the lenders have made safe loans.
LIFE INSURANCE COMPANY LOANS ON OIL & GAS PROPERTIES

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Presented at the Society of
Petroleum Evaluation Engineers' Annual Meeting
Houston, Texas
November 17-18, 1968

General Loan Considerations for Life Insurance Companies

Three broad considerations which apply to any investor are (1) security of principal; (2) yield; and, (3) liquidity. Of these, the most important is security of principal. Life insurance companies, like banks, do not invest their own funds, but funds of others. Policyowner reserves and other reserves for liabilities are analogous to a depositor's funds held by a bank, and equal about 91 percent of the average life insurance company's assets.

Life companies operate under state charters and are subject to regulation by the insurance commissions of the various states in which they operate. Investment policies in particular are subject to control. These state investment policies vary, but their purpose is to regulate the life company investments primarily into safe "fixed-dollar" investments in order to protect the asset value and policyowner reserve.

Within the framework of legal investments the life insurance company investment staff, of course, attempts to obtain the best yield possible for, like all business enterprises, life companies must make money to stay in business. Their constantly changing portfolios are a reflection of constantly changing investment opportunities.

Life companies are not as concerned with investment liquidity as commercial banks and other investors holding demand deposits, or other short-term obligations. Liabilities of a life insurance company are essentially long-term obligations, thus encouraging investment in long-term issues which offer more attractive rates of return. Considering all aspects of investments, a life insurance company will seek to keep its assets primarily in long-life securities. Revenue from premium payments, income from interest and maturing securities usually offer ample liquidity for day-to-day life insurance company operations.

Oil Loan History

Until about two years ago, oil loans and production payments were attractive investments for life companies even though they were of a comparatively short-life when related to other investments. First, they offered a much greater investment yield than the bond market and usually from one to two percent better interest return than the average residential or commercial mortgage loan. Also, the oil loan was usually for a larger amount than the average mortgage loan, thus, reducing service and overhead charges per dollar invested. In addition, oil investments were self-liquidating out of assigned pipeline runs.

But, in today's money market, the attractiveness of oil investment opportunities has changed. There has been a dramatic increase in yields offered by bond investments. For example, Composite "A" bonds in 1965 offered an average yield to maturity of 4% 1/2%. In 1966 such bonds averaged 5 1/4%, and in 1967—5 3/4%. This year we have seen the same bonds available at a yield of more than 6 1/4%.

In this same period the prime interest rate for mortgage loans has increased from 5 1/4% to 7 1/2%, and in the last 18 months we have commercial mortgages yielding a higher rate of interest than residential mortgages. Texas life insurance companies are now permitted to put limited investments into income producing real estate, and such ventures offer attractive equity investments for the insurance company dollar.

Oil loans must now compete with the bond market and the commercial mortgage loan market, which offer high yields, longer maturities, and better call protection. Oil loans must also compete with equity investments such as real estate and stocks. Some life companies that once invested in oil loans are not now attracted to this type investment. Most, like Southwestern Life, have money available, but competition from these other investment opportunities has (1) tended to increase the minimum size of oil loans that are now acceptable. (For example, at one time we would consider a $25,000 oil investment for our Company. Our minimum investment is now $100,000.) (2) tended to increase the minimum loan maturity. (For our Company, this minimum period has gone from 5 years up to 10 years); and (3) tended to increase the maximum loan maturity. (For our Company, this maximum maturity for loans has gone from 7 years up to 15 years.)

We find that prospective borrowers and production payment sellers are generally agreeable to the interest rates we ask on these investments, but are often unable to provide enough long-life producing properties to sustain a 10 to 15 year loan under life insurance company loan requirements.

One other point might be mentioned here—we find banks have now generally shortened the terms of the petroleum producing property investments they make, so there is a noticeable lack of interest in such investments that would ordinarily mature in 4 to 10 years. Some trusts, pension funds, and a few other lenders and production payment purchasers can sometimes be
found to fill this gap in financing, but in today's market we would say there is little money attracted to loans maturing between 4 and 10 years.

Legal Requirements of Oil Investments

Under the Texas Insurance Code, Authorized Investments and Loans for Domestic Life Insurance Companies, such companies are allowed to make loans secured by first liens on real estate, which include oil producing interests, provided title is good and the property value is at least 1/3 more than the amount loaned. In other words, we are legally allowed to loan 75% of the appraised value on any mortgage loan.

Prior to 1961 we participated in ABC transactions and in production payment financing by lending to the production payment purchaser, taking a first lien on the production payment as security, or by making a legally qualified corporate loan to the production payment purchaser.

Since 1961, however, Texas life companies have been allowed to purchase and own production payments directly.

This has eliminated the need for finding a willing production payment purchaser that would be able to borrow the money to finance the purchase. Domestic life companies, as we mentioned before, are now permitted to own certain income producing real estate, but ownership of leasehold or perpetual mineral interests is still prohibited.

Oil Loan Policy

In our general policy for oil and gas investments, we make both oil loans and production payment purchases, and we do make them with individuals and partnerships as well as corporations, although most other life companies make them only to corporate borrowers.

In considering individual or partnership borrowers, we first try to establish that they are knowledgeable, competent business men with satisfactory net worth. We must also establish that the property which will be security for our investment will be operated capably, whether by the borrower or a third party. This is especially important when we are considering a production payment purchase. For, unlike a loan where we have personal or corporate guarantees, we can look only to the property and its operation for security when purchasing a production payment.

For loans to corporations or large independents that have an established reputation within the industry, this is no problem, but in considering the small, independent operator, we do try to ascertain his operating record and ability as carefully as possible.

We loan only on developed and producing properties having a minimum of 18 months' producing history, preferably longer. Property diversification is preferred, but not essential, if we have what we consider an above-average property for collateral. We do not consider any loan or production payment purchase on a property containing less than two producing wells.

Generally, we, as do other life insurance companies, limit our oil loans and production payments to about 60% of the fair market value of the property. On occasion, we have loaned up to the legal 75% limit, but only where we have had an exceptional property for security and usually with a qualified corporate borrower.

We would probably limit any oil investment that we would consider to about one-half of one percent of our admitted assets. We have, though, for many years participated with large banks and other life insurance companies in loans and production payments and would be interested in considering participation up to our maximum loan limit in any large venture. When participating with banks, life insurance companies usually agree to let the banks have the early repayments of principal or primary amounts. Repayment of our oil investment is based on application of a certain percentage of the gross pipeline income as projected by the engineer's report. We require the loan or production payment to be amortized out of the first half of the net reserves securing our investment.

The loan or production payment is amortized monthly out of the pipeline runs which are assigned to us. As we mentioned before, the minimum term for oil loans is ten years and the maximum term is 15 years. We reserve the right to have up to 100% of the pipeline runs from the property interests securing our investment assigned to us under appropriate division or transfer orders. We tailor our loan amortization schedule to fit the borrower's needs for cash flow from the properties in order to insure he will have sufficient operating funds. We do, however, like to maintain a certain minimum repayment schedule and apply not less than 50% of the gross pipeline income toward servicing the investment.

Insurance companies are not banking institutions and do not want to rework or alter an investment once it is on the books. However, this is not to say that we never make exception to this rule. We have in the past, and will probably continue, deferring principal payments from time to time and, on occasion, extending the loans where the safety of our investment is not jeopardized. We prefer, however, that our borrowers depend on their banks rather than the insurance company for temporary, extra needs. We likewise do not want to allow any prepayments during the first half of the life of oil loans. We allow prepayments thereafter only with prepayment premiums.

On all applications for loans or production payment purchases, we require an up-to-date engineer's report furnished to us at the applicant's expense. This report must be made by an evaluation engineer acceptable to us. On loan applications above a certain minimum size, usually one million dollars, we may require reports from two such independent engineers.

We require a title opinion by an attorney selected by or approved by the Company. Attorney's fees, abstracting and recording fees, as well as any other closing costs, are paid by the applicant.
We can summarize the general guidelines and maximum loan limitations for life insurance company investments in producing oil properties by referring you to the booklet entitled “Valuation Procedures and Instructions for Bonds and Stocks”, prepared by the Committee on Valuation of Securities of the National Association of Life Insurance Commissioners (NAIC). This booklet is used in preparation of annual statements by life insurance companies, societies, and associations and is a standard guideline for life insurance company asset valuations. You will find in this booklet a section on the determination of values for oil and gas loans.

Engineer’s Reports

Our evaluation of any prospective oil investment is based on an up-to-date engineer’s report, addressed to us and furnished us by the prospective borrower. We require such reports to be made by an independent, competent, and experienced petroleum engineer whose reports have been found acceptable by other large lenders, including banks and life insurance companies. This report, for our evaluation purposes, must contain the following information:

1. A complete description of the property and interest being appraised.
2. The estimated gross reserves to the properties and the net reserves to the interest being appraised. They should be classified in accordance with the definitions for proved reserves adopted by the S.P.E.E. and S.P.E. for use when evaluating an individual property in an existing oil or gas field. Probable and possible reserves, if worth showing, should be listed separately and are usually not counted as security for oil investments by life insurance companies.
3. A projection of gross and net production by classification of reserves by years for a period exceeding the loan amortization by at least two years, the remainder, and the total for producing life.
4. Gross pipeline income (after production taxes) to the appraised interest by years for the required period, the remainder, and the total for producing life.
5. A similar projection of all operating expenses, including ad valorem taxes, but before general overhead, depreciation, depletion, or income taxes.
6. A similar projection of any capital expenditures by years.
7. The net cash flow (“future net operating income”) by years for the required period, the remainder, and the total for producing life.
8. A field inspection of the property and equipment and well tests as required by the appraisal engineer and us on certain properties.

9. The discounted present worth of the future net cash flow by months, usually now at a 6% discount rate, should be included.

Fair Market Value

The fair market value of an oil and gas producing property has been described in many ways from “price agreed on by a willing seller and a willing buyer” down to “dollars per net daily barrel produced” and other rule-of-thumb opinions. In our evaluations of property interests that are going to be used to secure our oil investments, we make engineering or analytical valuations based on the engineer’s report of projected net cash flow to those interests. Many different approaches to such valuations are used by knowledgeable evaluation engineers, bankers and other investors. For our purposes, we use the empirical market value yardstick developed by K. Marshall Fagin and presented in 1956. This yardstick is based on a number of oil and gas property sales with which he was familiar and which he analyzed over a 5-year period from 1951 to 1956. This yardstick has been referred to in several papers on valuation and may be found in the Petroleum Production Handbook by Thomas C. Frick, published in 1962. It is included in that book in John J. Arp’s chapter 38 on Valuation of Oil and Gas Reserves. For your reference, we have attached the yardstick to this paper.

Conclusions

The life insurance company investment dollar is exposed to ever-changing market conditions. Today, yields in the bond market and commercial mortgages and in some equity investments, together with the long-life aspects of such investments, have hurt the attractiveness of short-term oil investments.

Ten to fifteen year oil investments on profitable long-life properties based on acceptable engineering appraisals are still quite attractive investments for most life insurance companies.

Acknowledgements

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Mr. George A. W. Bundschuh
The Northwestern Mutual Life Insurance Company
Mr. John F. Konrad
Bibliography

5. Fagin, K. M.: An Empirical Yardstick for Appraising the Present Fair Market Value of Steady Future Net Operating Income from Oil & Gas Producing Properties

TABLE I

Empirical Yardstick for Appraising the Fair Market Value of Steady Future Net Operating Income from Oil & Gas Producing Properties

<table>
<thead>
<tr>
<th>Future Life, Years</th>
<th>Ratio: Fair Market Value to Future Net Operating Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.860</td>
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<tr>
<td>2</td>
<td>.814</td>
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<tr>
<td>3</td>
<td>.769</td>
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<td>4</td>
<td>.734</td>
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<td>5</td>
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<td>50</td>
<td>.260</td>
</tr>
<tr>
<td>55</td>
<td>.240</td>
</tr>
<tr>
<td>60</td>
<td>.222</td>
</tr>
</tbody>
</table>

For use with the Fair Market Value Yardstick, properties that are projected to produce increasing or declining rates of future net operating income may be converted to equivalent years of steady future net operating income in the following manner:

(1). Find the present worth of the projected income by the use of appropriate present worth factors, using any selected discount rate.

(2). Divide the present worth of this cash flow by the undiscounted cash flow to find the “average” present worth factor.

(3). Using “Present Worth of 1 Per Period” tables at the same discount rate selected in (1) above, find the Present Worth of 1 Per Period which, divided by its period, will give the same present worth factor found in (2) above.

(4). This period is equal to the “average” steady life of the future net operating income of the property, which is shown on the “yardstick” as “Future Life, Years.”

(5). The fair market value of the property being appraised is simply the future net operating income times the decimal ratio for the period determined above.

Income from Oil and Gas Producing Properties, Study Group Meeting, Dallas Section AIME, November 1, 1956.
6. Valuation Procedures and Instructions for Bonds and Stocks for use in the preparation of Annual Statements by Insurance Companies, Societies and Associations for the year ending December 31, 1967; Committee on Valuation of Securities of the National Association of Insurance Commissioners.
THE SKIN EFFECT IN PRODUCING WELLS

By William Hurst, Petroleum Consultant, Houston, Texas, J. Donald Clark, and E. Bernard Brauer, Members AIME, Union Oil Co. of California, Houston, Texas

This paper was presented at the fall meeting of the AIME, Houston, Texas, Oct., 1967, SPE 1854

ABSTRACT

What is developed in this paper is the cumulative fluid flow across the resistance existing at the wellbore. This is the skin effect that is encountered that is treated here for both positive and negative skin.

Essentially, what is reproduced are work curves where the cumulative fluid produced vs dimensionless time are related to the different values for the skin effect.

In treating with the negative skin in connection with the cumulative fluid produced, it has been learned that the mathematical model that designates such a skin to exist at the wellbore cannot apply, but what is attained is an effectively increased wellbore radius beyond the well bit size that shows the influence of fracturing or any remedial work performed on the well. Thus, the matrix of the sand is effected to evidence discontinuity in the pressure drop for the fluid flowing toward the well; and for the increased effective wellbore radius to the wellbore proper, the flowing pressure is essentially constant. Thus, the mathematical model indicates an open network can exist in the region of the well if the flow is radial and such is shown by the Lord Kelvin effect in pressure buildup.

References and illustrations at end of paper.

REFERENCES


INTRODUCTION

The basis for this work is the Laplace transformation published by van Everdingen and Hurst, for which the present paper is an extension of the necessary work curves, incorporating the mathematics for the skin effect. The skin effect is also the joint undertaking of these authors published separately in the literature.

It is shown in the first mentioned publication that the cumulative fluid influx into a wellbore is expressed by

\[ Q(t) = 2\pi \Phi r_w^2 \int_0^{t_D} \frac{Q(t_D-t')}{t_D} dt' \]

subject to transient fluid flow or unsteady-state flow, where \( Q(t_D) \), the mathematical symbol for fluid influx, is a function of the physical parameters in the reservoir or

\[ t_D = \frac{k\tau}{\mu r_w^2} \]

Employing the superposition theorem for instantaneous pressure drop observed in the production history, the former equation is expressed as

\[ Q(t) = 2\pi \Phi r_w^2 \left[ \Delta P_0 Q(t_0) + \Delta P_1 Q(t_0-t_01) \right. \\
+ \left. \Delta P_2 Q(t_0-t_02) + \cdots \right] \]
The values for \( q(t_0) \) have been reported extensively in that publication, and such is expressed by

\[
Q(t) = \frac{4}{\pi^2} \int_0^\infty \frac{1 - e^{-u^2 t_0}}{u^3 \left[ J_0^2(u) + Y_0^2(u) \right]} \, du \quad [3]
\]

given in Bessel functions of the first and second kind of zero order for radial flow.

The change that now appears in these formulas is due to the skin effect, which can be expressed simply by the cumulative pressure drop as

\[
\Delta p = \frac{q(t) \mu}{2 \pi \, p \cdot k \cdot h} \left[ S + p (t_0) \right] \quad [5]
\]

subject to a constant rate of production at the well, with \( P(t_0) \) the cumulative pressure drop for a unit rate of production, which in turn is a function of time and unsteady-state fluid flow.

Its accumulative fluid influx for a positive skin effect applicable in Eq. 1 is now given as

\[
Q(t_0) = \frac{4}{\pi^2} \int_0^\infty \frac{1 - e^{-u^2 t_0}}{u^3 \left\{ [J_0(u) + u S J_1(u)] + [Y_0(u) + u S Y_1(u)]^2 \right\}} \, du \quad [6]
\]

Thus, Eq. 6 is the identity of Eq. 4 when no skin effect exists, and in itself forms the basis of the work entailed here. What is meticulously reported is for a positive skin; if a negative skin occurs, an additional term appears in Eq. 6 that is a reversal of fluid flow and the mathematical model can no longer apply.

ANALYSES

The skin effect as defined in the early papers is an impediment that exists around the wellbore and retards the fluid flow into the well. Its graphical picture as shown in the original sketch, Fig. 1, is that immediately at the well there is an incrustation, that these authors defined as the damaging of the well by the drilling operation that offers a lower permeability than the formation proper, and as a result there is a discontinuity in the flow of fluids once this barrier is reached and the greatest pressure drop takes place in the fluids flowing into the well. In a sense this has been regarded as an infinitesimal thickness, and the appendage of a skin effect assigned to identify this phenomenon is comparable to the film coefficient of heat transfer.

This is one version; others have subscribed partial penetration to the skin effect, some to the second order velocity gas can obtain if turbulence exists at the wellbore. All this may be true and a condensation of these effects; the significant thing is that in interpreting pressure buildup Darcy's law is readily manifested at earliest times by the Lord Kelvin effect of pressure buildup vs logarithm of time, and if one extrapolates back to the time of flow, an additional pressure increase is observed above the flowing pressure that is this skin effect.

Such has been the performance of many of these pressure buildup tests, and with the advent of fracturing and large scale remedial operations on wells, a reversal of these conditions has been observed where the pressure is lower than the flowing pressure in extrapolating back to earliest times. This is the negative skin effect.

Thus, in its implication and meaning, it is recognized that a positive skin terminates at the wellbore because this is its physical limit. A negative skin, however, offers further thought as the mathematical model does not apply for the explicit interpretation of a skin.

Rather than regarding this aspect as a failure or a limitation of analyses in employing the skin, it offers the only alternative that a skin cannot exist under these conditions and the sand matrix is effected further than the physical boundaries for a skin.

The Laplace transform for the influx of fluid that identifies this skin follows from the earlier paper, given by the equation

\[
\frac{1}{P^2} = p \bar{P}(p) \bar{Q}(p) \quad [7]
\]

where \( \bar{P}(p) \) is the cumulative pressure drop for a unit rate of production, expressed in operational form, with \( p \) the operator for dimensionless time, \( t_p \). \( \bar{Q}(p) \) is the cumulative production for a fixed terminal pressure, also given as a Laplace transform. It is this latter term we wish to identify when the skin effect exists.

The development of this formula, although shown as a generalized relation for these two boundary problems, can here be specifically identified with the skin effect by treating Eq. 5 for the unit rate of production in Laplace transformations, or

\[
\bar{P}(p) = \frac{S + \bar{P}(p)}{p} \quad [8]
\]

Such introduced in Eq. 7, gives

\[
\bar{Q}(p) = \frac{1}{p^2 \left[ S + p \bar{P}(p) \right]} \quad [9]
\]
This is the development of Eq. 6 employing the Mellin's inversion formula, where \( \bar{p}(p) \) is the pressure drop for the unit rate of production of the undamaged or clean sand, with

\[
\bar{p}(p) = \frac{K_0(\sqrt{p})}{p^{3/2}K_1(\sqrt{p})}
\] ........................ [10]

expressed in modified Bessel functions.

An alternate solution to this problem is to use the actual boundary conditions shown in Fig. 1. This is the fixed terminal pressure case. The initial pressure \( P_i \) is also constant and extends throughout the formation to infinity.

If we recognize in Eq. 5 the component pressure drop that is the skin effect, then

\[
P_i - P_{wf} = \frac{q \mu S}{2 \pi kt} \] ........................ [11]

and with the rate of fluid production at the wellbore

\[
q = \frac{2 \pi kh}{\mu} \left( \frac{\partial p}{\partial r} \right)_{rw}
\] ........................ [12]

therefore,

\[
P_i - P_{wf} = \left( \frac{\partial p}{\partial r} \right)_{rw} \] ........................ [13]

and it is the condition that must be met for \( r_w = 1 \).

The cumulative pressure drop from \( P_i \) expressed as a Laplace transformation is given\(^1\) as

\[
\bar{p}(r) = \bar{A}K_0(r \sqrt{p})
\] ........................ [14]

where \( A \) is a constant. Therefore, the pressure in the formation is expressed as

\[
\bar{p}(r) = \bar{P}(p) - \bar{A} K_0(r \sqrt{p})
\] ........................ [15]

Its substitution in Eq. 13, yields

\[
\frac{(P_i - P_{wf})}{p} = \bar{A}K_0(\sqrt{p}) = A \sqrt{p} K_1(\sqrt{p})
\] ........................ [16]

for \( r_w = 1 \), and

\[
\bar{A} = \frac{(P_i - P_{wf})}{p \left[ K_0(\sqrt{p}) + S \sqrt{p} K_1(\sqrt{p}) \right]}
\] ........................ [17]

where \( K'_0(z) = -K_1(z) \). Therefore

\[
\bar{p}(r) = \frac{P_i}{p}
\]

This is the pressure distribution in Laplace transformations when a skin effect exists at the wellbore and it is compatible with a solution by Carslaw.\(^5\)

The interpretation of Eq. 12 as the fluid flux just upstream from the skin gives

\[
\bar{q} = \frac{2 \pi kh}{\mu} \frac{P_i - P_{wf}}{\sqrt{p}} \frac{K_1(\sqrt{p})}{K_0(\sqrt{p}) + S \sqrt{p} K_1(\sqrt{p})}
\] ........................ [19]

Its integration with absolute time, although made necessarily in dimensionless time as expressed through the operator \( p \), and

\[
\bar{Q}(p) = \frac{\Phi \mu r_w^2}{k} \bar{q}
\]

\[
= \frac{2 \pi \Phi \mu r_w^2}{\mu} \frac{(P_i - P_{wf}) K_1(\sqrt{p})}{p^{3/2} \left[ K_0(\sqrt{p}) + S \sqrt{p} K_1(\sqrt{p}) \right]}
\] ........................ [20]

This is the form of Eq. 1, or more appropriate, Eq. 3, when only a fixed pressure drop \( P_i - P_{wf} \) prevails at the wellbore. Therefore, \( \bar{Q}(p) \) as expressed independent of these coefficients is given as

\[
\bar{Q}(p) = \frac{K_1(\sqrt{p})}{p^{3/2} \left[ K_0(\sqrt{p}) + S \sqrt{p} K_1(\sqrt{p}) \right]}
\] ........................ [21]

which is Eq. 9, upon substituting in Eq. 10.

**NUMERICAL INTERPRETATION**

The inordinate time it takes to program a calculation to arrive at numerical values, particularly of the complex nature of the Bessel functions with their oscillatory characteristics of the type of Eq. 6, suggests the simplification of Eq. 21 in employing the Mellin's inversion formula.

To make this as adaptable as possible for a computer calculation, it is recognized that if \( t_p \) is large, \( p \) is small, since for the fluid
influx into a well t_p is significantly large in a matter of seconds from the start of production, employing the necessary reservoir parameters.

This application is again referred to the basic paper\(^1\) where Eq. 10 for p small is given as

\[ \tilde{P}(p) = \frac{1}{p} \left[ -\ln p + (\ln 2 - \gamma) \right], \ldots [22] \]

with \( \gamma = 0.57722 \), the Euler's constant. Substituted in Eq. 9, it yields

\[ \tilde{Q}(p) = \frac{1}{p^2 \left[ S - \ln p + (\ln 2 - \gamma) \right]}, \ldots [23] \]

now introducing the skin effect as such retards the fluid entry.

Its inversion follows along the "cut" of the negative real axis of the \( \{x, y\} \) coordinates employing the Mellin's inversion formula

\[ Q(t_0) = \frac{1}{2\pi i} \int_{\gamma - i\infty}^{\gamma + i\infty} e^{\lambda t_0} \tilde{Q}(\lambda) d\lambda, [24] \]

where \( \lambda \) is related to these coordinates as \( \lambda = x + iy \), or in polar coordinates \( \lambda = r e^{i\theta} \), whichever is most suited, and \( \gamma \) is the distance removed on the positive real axis parallel to the \( y \) coordinate that includes all poles observed for \( \tilde{Q}(\lambda) \) to the left of this line. The \( \lambda \) mentioned here is the operator \( p \) in Eq. 23.

The discussion of this inversion has now received considerable reference in the literature, and it suffices to report this inversion of Eq. 23 without engaging in mathematics. Thus, the alternate form to Eq. 6, is

\[ Q(t_0) = \int_{0}^{\infty} \frac{1 - e^{-u^2 t_0}}{u^3 \left[ S - \ln u + (\ln 2 - \gamma) \right]^2 + \frac{\pi^2}{4}} du \ldots [25] \]

when \( t_0 \) is large and suitable for machine calculation.

For \( u \) close to the zero, an additional equation results from Eq. 25, as that form cannot handle the integration at the origin. This is for \( u = 0 = \sqrt{0.04/t_0} \), which has been learned from experience is appropriate in breaking up this integration. Thus, for Eq. 25, and integrating from 0 to \( u \), gives

\[ Q_\delta(t_0) = \frac{1}{2} \int_{0}^{\infty} \frac{1 - e^{-u^2 t_0}}{u^3 \left[ S - \ln u + (\ln 2 - \gamma) \right]^2 + \frac{\pi^2}{4}} du \ldots [26] \]

where \( 1 - e^{-u^2 t_0} \approx u^2 t_0^2 \). By changing the variable and letting \( u = e^{\frac{x}{\sqrt{2}} v} \) the above reduces to

\[ Q_\delta(t_0) = t_0 \int_{0}^{\infty} \frac{dv}{\ln \frac{1}{\delta} \left[ S + v + (\ln 2 - \gamma) \right]^2 + \frac{\pi^2}{4}} [27] \]

Furthermore, for \( m = \frac{2}{\pi} \left[ S + \gamma + (\ln 2 - \gamma) \right] \) this becomes

\[ Q_\delta(t_0) = \frac{2}{\pi^2} t_0 \int_{0}^{\infty} \frac{dm}{m^2 + 1}, [28] \]

that yields

\[ Q_\delta(t_0) = \frac{2}{\pi^2} t_0 \tan^{-1} m \left[ \frac{2}{\pi} \left( S + \ln \frac{1}{\delta} + \ln 2 - \gamma \right) \right] \ldots [29] \]

It has been learned that numerically this is the largest part of the contribution of Eq. 25 when the skin effect is positive.

The results obtained for \( Q(t_p) \) from Eqs. 25 and 29 are shown in Table 1 for a positive skin effect extending from 0, 2.5, 5, 10, 15, 25 and 50, listed vs dimensionless time \( t_p \) 100 to 10,000,000.

These calculations are shown plotted in Fig. 2 as log of \( Q(t_p) \) vs log \( t_p \) for the specific skin effect identified. As will be observed from this plot, the greater the value of the skin, the larger the impedance to fluid flow into the well, yielding a lowered efflux of fluid issuing from the well for a given time, \( t_p \).

The check on the validity of these equations and computations can be immediately evidenced to the reader by comparing the fourth and fifth columns of Table 1 in the Laplace transformation\(^2\) with \( S = 0 \) in Table 1 cited here to show that the values are almost identical.

Other numerical checks have been made of individual calculations of the computer, but what has been stated suffices to show the reliability of this procedure.
The interest here, however, has been to identify what evidence can be given as to the physical problem when the skin effect is negative as manifested by the pressure buildup for a fractured or remedial treated well. This amounts to $S$ being negative in these equations, but such is not the complete solution as we must treat with an essential singularity along the positive real axis in the Mellin's inversion formula. This refers back to Eq. 24 and the significance of that formula.

In effect the development of Eq. 6 when treating with the Bessel functions, and then Eq. 25 when dealing with the simple transcendental function of the logarithm of the operator, has been performed by substituting $\lambda$ in Eq. 24 as $\lambda = u^{2}e^{i\pi}$, in making the integration along the negative real axis from zero to infinity as indicated for the direction of the cut along the negative real axis shown in Fig. 3.

However, what is also indicated is that for a negative skin effect a pole also resides on the positive real axis illustrated in Fig. 3. This refers back to the Laplace transformation for $q(t)$, Eq. 9, when $S$ is negative, or as observed in Eq. 21.

$$Q(p) = \frac{K_{1}(\sqrt{p})}{p^{3/2}[K_{0}(\sqrt{p}) - 5\sqrt{p}K_{1}(\sqrt{p})]}.$$  [30]

As before, the cut extends along the negative real axis, but also observed is that the term in the bracket of the denominator becomes zero when

$$S = \frac{K_{0}(\sqrt{v})}{\sqrt{K_{1}(\sqrt{v})}}, \quad \ldots \ldots \ldots [31]$$

with $v = \frac{1}{p}$, the root when this identity is met.

It does not prevail along the negative real axis, but for positive values for $v$ these are single valued Bessel functions to reveal poles for the whole range of $S$ from zero to infinity when substituted in Eq. 31.

Its residual as subscribed in Eq. 24, is

$$Q(t) = \frac{e^{v't}K_{1}(\sqrt{v})}{\sqrt{v}d[K_{0}(\sqrt{v}) - S\sqrt{v}K_{1}(\sqrt{v})]} \bigg|_{p \to v} \ldots \ldots \ldots \ldots \ldots [32]$$

to yield

$$Q(t) = \frac{2e^{v't}K_{1}(\sqrt{v})}{\sqrt{\left[-S_{K_{1}(\sqrt{v})} - \sqrt{S_{K_{1}(\sqrt{v})} + K_{1}(\sqrt{v})}\right]},}$$

and by the differentiation of these modified Bessel functions, where

$$K_{0}'(z) = -K_{1}(z)$$

$$K_{1}'(z) = -K_{0}(z) - \frac{K_{1}(z)}{z} \ldots \ldots [34]$$

given in the literature, yields

$$Q(t) = \frac{2e^{v't}K_{1}(\sqrt{v})}{\sqrt{\left[-S_{K_{1}(\sqrt{v})} - \sqrt{S_{K_{1}(\sqrt{v})} + K_{1}(\sqrt{v})}\right]},}$$

Thus, upon substituting the identity Eq. 31, gives

$$Q(t) = \frac{2e^{v't}/\sqrt{s_{2} - 1}}{\sqrt{\left[-S_{K_{1}(\sqrt{v})} - \sqrt{S_{K_{1}(\sqrt{v})} + K_{1}(\sqrt{v})}\right]},}$$

which upon introducing the limits for $q(t)$ production in $t_{f}$ time, and zero production in time zero, yields

$$Q(t) = \frac{2e^{v't}/\sqrt{1 - vS^{2}}}{\sqrt{\left[-S_{K_{1}(\sqrt{v})} - \sqrt{S_{K_{1}(\sqrt{v})} + K_{1}(\sqrt{v})}\right]},}$$

From the observation of the asymptotic expansions for $q(t)$ as defined by these modified Bessel functions, $vS^{2} < 1$, except when $S$ is infinity; thus, the contribution of the essential singularity along the positive real axis is always negative as $e^{v't} \geq 1$.

These are the results now shown as a plot in Fig. 4, which are the contributions of Eqs. 25, 29 and 37 when $S$ is negative, with the latter the largest contributory value to give negative efflux, or specifically fluid influx for $q(t)$.

In a sense, what is recognized is a situation where some form of pressure maintenance or fluid injection into a well is superimposed above the initial pressure. This occurs when pressure is given to a negative skin effect as required in these formulas.

It is necessary to determine exactly what this physical problem is, and whether such is tangible to sustain such a case, since the mathematics makes no distinction as to what is introduced for the skin effect.

This refers back to the physical problem and boundary conditions stated for Fig. 1, but now identified with fluid injection as shown in Fig. 5. This is for fluid injected into a well, encountering a skin effect, with the resulting pressure superimposed above the initial pressure.

As in Eq. 13, the boundary conditions at the skin effect can be stated as
\[ P_{wf} - P_f = -S \left( \frac{\partial P}{\partial r} \right)_{rw}, \quad \ldots \quad [38] \]
giving full recognition that the well pressure will be greater than the interfacial pressure past the skin. Further, the skin itself will be identified for its absolute value of positive skin determined for a damaged well. Here the minus sign is affixed to the right of the equation as the slope of the pressure gradient will be negative for fluid moving into the formation. Thus, the combined effect yields the positive value necessary for \( P_{wf} > P_f \).

As in the earlier development, the Laplace transformation for pressure in the formation is given as
\[
\mathbf{\tilde{p}}(r,p) = \frac{p_i}{p} + A K_0(\sqrt{\frac{p}{r}}) \quad \ldots \quad [39]
\]
for which \( A \) is established from Eq. 38 in substituting \( P_f \), or
\[
\frac{P_{wf} - P_i}{p} = -A K_0(\sqrt{\frac{p}{r}}) = AS K_1(\sqrt{\frac{p}{r}}) \quad [40]
\]
at \( r = r_w \),
and
\[
A = \left( \frac{P_{wf} - P_i}{p} \right) \frac{1}{\left[ K_0(\sqrt{\frac{p}{r}}) + S \sqrt{p} K_1(\sqrt{\frac{p}{r}}) \right]} \quad [41]
\]
with the pressure in Eq. 39, given as
\[
\mathbf{\tilde{p}}(r,p) = \frac{p_i}{p} + \left( \frac{P_{wf} - P_i}{p} \right) \frac{K_0(\sqrt{\frac{p}{r}})}{\left[ K_0(\sqrt{\frac{p}{r}}) + S \sqrt{p} K_1(\sqrt{\frac{p}{r}}) \right]} \quad [42]
\]
This suffices for the present development as it is recognized from Eq. 18, and now Eq. 42, that this unsteady-state fluid injection, for which \( P_{wf} - P_i \) is fixed, and the work curves shown in Fig. 2 for a positive skin effect apply.

The question is, what gives the form of Eqs. 30 that can interject a negative skin in the pressure influx formulas. This goes back to Eq. 38, and to give full cognizance to S for a negative skin, thus recognizing its algebraic sign. Therefore, Eq. 38 becomes
\[
P_{wf} - P_f = S \left( \frac{\partial P}{\partial r} \right)_{rw} \quad \ldots \quad [43]
\]
If we repeat the steps of the previous development, then we observe that the operational pressure in the formation is
\[
\mathbf{\tilde{p}}(r,p) = \frac{p_i}{p} + \left( \frac{P_{wf} - P_i}{p} \right) \frac{K_0(\sqrt{\frac{p}{r}})}{\left[ K_0(\sqrt{\frac{p}{r}}) - S \sqrt{p} K_1(\sqrt{\frac{p}{r}}) \right]} \quad \ldots \quad [44]
\]
This is the first time we observe the operational form that leads to Eq. 30 for a negative skin.

In order to understand what is implied by a negative skin, it is necessary to make the inversion for Eq. 44. This is given by the pressure distribution relationship
\[
P(r,t_0) = p_i + \frac{k_i(r,t_0)}{r} \int_{t_0}^{t} \left[ \frac{1}{k_0(\sqrt{\frac{p}{r}})} \left( \frac{P_{wf} - P_i}{p} \right) K_0(\sqrt{\frac{p}{r}}) \right] \quad [45]
\]
with the initial pressure being the static pressure \( P_i \) at time zero.

The second term is the cumulative pressure drop for the superimposed pressure injected from well pressure \( P_{wf} \), to static pressure \( P_i \), which in these mathematical formulas show that even with a negative skin, fluid flows into the formation proper. However, the contribution of the pole on the positive real axis of Fig. 3 in this inversion shows that a sink is generated of unlimited extent with time. This is the third term in Eq. 45.

The result is that the entire formula for pressure distribution is projected as if this were an accumulative pressure drop from \( P_i \) for fluid flowing into the well, which is the predominance of this term. This is indicated by the negative values for \( q[t_0] \) in Fig. 4, of fluid entering the well from the formation. A situation incompatible for the boundary conditions set forth in this problem illustrates the lack of any physical significance that could be attached to a mathematical model for a negative skin effect.

In substance, a pole along the positive real axis generates a source or sink of uncontrollable extent with time. Yet that this pole exists is dictated by mathematical procedure indicated by Eqs. 30 and 31 and proves that a negative skin is untenable.

Yet for pressure buildups after fracturing or remedial treating a well, the numerical interpretation of such tests shows that the skin can be negative in value. By a process of elimination undertaken here one other interpretation exists—that the matrix of a sand can be affected.
This can be evidenced from Eq. 5, subscribing a negative skin, and writing out the full meaning for \( P(t_p) \) as would apply to a pressure buildup:

\[
\Delta P = \frac{q \mu}{4\pi \kappa h} \left[ -2S + \ln \left( \frac{k t}{\Phi \mu c r_w^2} \right) + 0.80907 \right],
\]

where \( t \) is the time of buildup yielding the Lord Kelvin effect.

If we let \( r_w \) represent the apparent or increased wellbore radius by fracturing beyond the actual wellbore radius drilled, \( r_w \), then

\[
-S = \ln \left( \frac{r_w}{r_w} \right).
\]

where \( r_w \leq r_w \) that yields a negative value for \( S \) and its substitution in the above formula, gives

\[
\Delta P = \frac{q \mu}{4\pi \kappa h} \left[ \ln \left( \frac{k t}{\Phi \mu c r_w^2} \right) + 0.80907 \right],
\]

which is also a Lord Kelvin effect. Its physical aspect is illustrated in Fig. 6.

While the effect of a negative skin from the ordinary interpretation of a pressure buildup is to give a lower wellbore pressure than that observed prior to buildup, the configuration of Fig. 6 shows that the matrix of the sand is discontinuous at a distance \( r_w \) to give a uniform pressure \( P_w \) to the wellbore radius \( r_w \), which is the only means for sustaining fluid flow into the well itself.

Mathematical conversions similar to Eq. 47 have been used in the past to incorporate the skin effect with the wellbore boundary conditions, but what is revealed in this work is that by a process of elimination an enlarged wellbore radius is the only condition that can sustain a negative skin if it is observed upon pressure buildup, which is a measure of the effectiveness of fracturing or other remedial operations, provided of course the Lord Kelvin effect is pronounced in the buildup.

The last assertion made as such is the criterion of what is developed here. This is limited to one system, radial interpretation of fracturing that appears upon many tests as evidenced from pressure builds. Yet the authors are cognizant that other systems can prevail. In this respect one of us may be joined in such an undertaking with an associate to encompass yet a different system.

Recognizing that an enlarged wellbore is the only basis that can explain a negative skin effect, the cumulative fluid influx readily follows. This is to treat the enlarged radius \( r_w \) as free of any skin effect, or \( S \) equal to zero, and equating the following relation:

\[
r_w^2 Q \left( \frac{t_D - \frac{k t}{\Phi \mu c r_w^2}}{\frac{k t}{\Phi \mu c r_w^2}} \right) = r_w^2 Q \left( \frac{t_D = \frac{k t}{\Phi \mu c r_w^2}}{\frac{k t}{\Phi \mu c r_w^2}} \right)
\]

This reduces the effective increased wellbore radius to a unit radius that is mandatory to apply for \( Q(t_D = \frac{k t}{\Phi \mu c r_w^2}) \) at the wellbore in Eqs. 1 or 3.

It could be assumed that the affected sand [either fractured or acidized] is already filled with the treating fluid in the immediate wellbore area, and there is an instantaneous relationship of one fluid displacing another in the movement of oil to the well.

The time \( t_D = \frac{k t}{\Phi \mu c r_w^2} \) will necessarily be much smaller than the corresponding time, \( t_D = \frac{k t}{\Phi \mu c r_w^2} \) for the well radius. Yet Table 1 in the Laplace transformation will readily apply to small dimensionless time to \( t_D = 0.01 \). For less than this value the reader can use \( t_D = 2 t_5^{1/2} \pi^{-1/2} \), given in that paper. Such are now reproduced with the positive skin effect shown in Fig. 7. The summary of values for the negative skin are given in Table 2.

To summarize, the basis for this work has been to observe the work curves for cumulative fluid influx, Fig. 2, when a skin effect exists. The fact that we have been taken further afield by the mathematics that appeared upon applying the negative skin effect necessarily made it mandatory to pursue the problem that resolved itself that a negative skin cannot exist except as an enlarged wellbore radius, which is the purpose for the presentation.

The measure of the success of the degree of fracturing by this increased wellbore radius has now been reported to the Corporation Commission of Kansas in the study of the Kansas Hugoton Field. It has been learned there in comparing the performance of early completed wells with recently fractured wells that what is now accomplished in fracturing these wells is to restore their gas deliverability somewhere near to the capacity of the earlier wells. This is not surprising as over the years with the wells in operation a large amount of debris from sand deposited, and even connate water, has collected in these wells, and fracturing is restoring these wells nearly to their early performance as observed in making this comparison for the effective increased wellbore radius of the early unfractured wells with the fractured wells.
ACKNOWLEDGMENT

Appreciation is extended to the management of Union Oil Co. of California for permission to present this paper.

NOMENCLATURE

- \( c \) = fluid compressibility, \( \text{Lt}^2/\text{m} \)
- \( h \) = reservoir thickness normal to flow, \( \text{L} \)
- \( k \) = effective permeability, \( \text{L}^2 \)
- \( \mu \) = viscosity, \( \text{m/lt} \)
- \( \phi \) = porosity
- \( P \) = pressure, \( \text{m/lt}^2 \)
- \( P_r \) = formation pressure, \( \text{m/lt}^2 \)
- \( P_i \) = initial pressure, \( \text{m/lt}^2 \)
- \( P_{w0} \) = wellbore pressure, \( \text{m/lt}^2 \)
- \( P_i \) = dimensionless pressure
- \( Q(t) \) = fluid efflux
- \( r_w \) = wellbore radius, \( \text{L} \)
- \( r_{wa} \) = apparent wellbore radius, \( \text{L} \)
- \( s \) = skin effect
- \( t \) = time, \( \text{t} \)
- \( t_D \) = dimensionless time

REFERENCES

| $n$ | $\hat{t}$ | $3t$ | $10.3-31.01$ | $903.00$ | $243,342.46$ | $1,030,330$ | $41,444$ | $1971$ | $304,403.45$ | $900$ | $1,04,403.45$ | $400$ | $1,030,000$ | $3,000,000$ | $1,030,000$ | $2.068.00$ | $109,23$ | $20,38$ | $1,379,40$ | $3,424.34$ | $1,39,33$ | $2,040,34$ | $3,708.40$ | $1,39,19.44$ | $2,31,84.44$ | $3,70,23.81$ | $1.141,55$ | $1,04,403.45$ | $304,403.45$ | $1,030,000$ | $3,000,000$ |
|-----|------|-----|------------|--------|-------------|-------------|----------|------|-------------|------|-------------|------|-------------|----------|-------------|-------------|----------|------|-------------|------|-------------|------|-------------|----------|-------------|----------|-------------|------|-------------|----------|-------------|----------|-------------|------|-------------|
| 1.00 | 40,72 | 21,15 | 12,88 | 14,09 | 9,46 | 3,46 | 3,68 | 1,93 | 1,141,55 | 1,04,403.45 | 304,403.45 | 1,030,000 | 3,000,000 | 1,030,000 | 2.068.00 | 109,23 | 20,38 | 1,379,40 | 3,424.34 | 1,39,33 | 2,040,34 | 3,708.40 | 1,39,19.44 | 2,31,84.44 | 3,70,23.81 | 1.141,55 | 1,04,403.45 | 304,403.45 | 1,030,000 | 3,000,000 |
WELL EOR
3G4PC
LLIS3RO
OF cu
MELLN$JNYrN
FORMULA
F4H"
SXN
EF
ECT
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F
DAMAGED WELL BORE

Fig 1 - DAMAGED WELL BORE

Fig 2 - CUMULATIVE FLUID EFFLUX FOR POSITIVE SKIN EFFECT

Fig 3 - GRAPHICAL ILLUSTRATION OF 'CUT' IN MELLIN'S INVERSION FORMULA

Fig 4 - CUMULATIVE FLUID INFUX FOR NEGATIVE SKIN EFFECT
Fig 5 - Fluid injection superimposed above the initial pressure

Fig 6 - Effective well bore radius for negative skin

Fig 7 - Cumulative fluid influx for positive skin and increased effective well bore radius
In Memorial

IRA BRINKERHOFF

It is indeed sad just before going to press with the Journal of The Society of Petroleum Evaluation Engineers, to announce of the deceasement of Mr. Ira Brinkerhoff, one of the early members of this Society.

Mr. Ira Brinkerhoff, often referred to as “Brink,” died in his home in Houston, Texas, September 21, 1969. Funeral services were held in this city, and interment was in Eureka, Kansas.

Ira Brinkerhoff was a well known geologist and evaluator of oil and gas properties. He has been in private consulting practice in Houston, Texas, for many years.

Ira Brinkerhoff was born at the turn of the century in Kansas. He attended the Loomis School, preparatory school for boys in Windsor, Connecticut, and graduated with a B.S. degree in geology from the University of Nebraska.

He had a varied experience in his activities as a geologist. To summarize some of his more important employment; he worked as a geologist for the Stanolind Oil & Gas Co., then he was chief geologist for the Texas-Gulf Producing Co., Houston, Texas. He joined the consulting firm of Cummins, Berger, and Pishney in 1947, to become an independent consultant under his own name in 1954.

To his wife, Mrs. Ira Brinkerhoff, who we always addressed affectionately as ‘Hreesche,” and his two daughters, Mrs. Bernard A. Scofield of Seattle, Washington, and Mrs. Keith Vander Zee of Houston, Texas, as well as his grandchildren, we extend our deepest sympathy on the passing of Mr. Ira Brinkerhoff.

THE EDITOR