

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CHINA CHENGDA ENGINEERING CO. LTD.,
Petitioner

v.

DORIAMO LTD
Patent Owner

Case No. Unassigned
Patent 8,591,852

DECLARATION OF SYLVIA D. HALL-ELLIS, PH.D.

I. INTRODUCTION

1. My name is Sylvia D. Hall-Ellis. I have been retained as an expert by Petitioner.

2. I have written this declaration at the request of Petitioner to provide my expert opinion regarding the authenticity and public availability of several publications. My report sets forth my opinions in detail and provides the bases for my opinions regarding the public availability of these publications.

3. I reserve the right to supplement or amend my opinions, and bases for them, in response any additional evidence, testimony, discovery, argument, and/or other additional information that may be provided to or obtained by me after the date of this declaration.

4. I am being compensated for my time spent working on this matter at my normal consulting rate of \$325 per hour, plus reimbursement for any additional reasonable expenses. My compensation is not in any way tied to the content of this Declaration, the substance of my opinions, or the outcome of this dispute. I have no other interests in this proceeding or with any of the parties.

5. All of the materials that I considered are discussed explicitly in this Declaration.

II. QUALIFICATIONS

6. I am currently an Adjunct Professor in the School of Information at San José State University. I obtained a Master of Library Science from the University of North Texas in 1972 and a Ph.D. in Library and Information Science from the University of Pittsburgh in 1985. Over the last fifty years, I have held various positions in the field of library and information resources. I was first employed as a librarian in 1966 and have been involved in the field of library sciences since, holding numerous positions.

7. I am a member of the American Library Association (“ALA”) and its Association for Library Collections & Technical Services (“ALCTS”) Division, and I served on the Committee on Cataloging: Resource and Description (which wrote the new cataloging rules) and as the founding chair of the Committee for Education and Training of Catalogers and the Competencies and Education for a Career in Cataloging Interest Group. I also served as the Founding Chair of the ALCTS Division’s Task Force on Competencies and Education for a Career in Cataloging. Additionally, I served as the Chair for the ALA Office of Diversity’s Committee on Diversity, a member of the REFORMA National Board of Directors, a member of the Editorial Board for the ALCTS premier cataloging journal, *Library Resources and Technical Services*, and as a Co-Chair for the

Membership Committee of the Library Research Round Table (LRRT) of the American Library Association. Currently I serve as a member of the LRRT Nominating Committee.

8. I have also given over one-hundred presentations in the field, including several on library cataloging systems and Machine-Readable Cataloging (“MARC”) standards. My current research interests include library cataloging systems, metadata, and organization of electronic resources.

9. I have been deposed twenty-six times: (1) *Symantec Corp. v. Finjan, Inc.*, Petition for *Inter Partes Review* of U.S. Patent No. 7,613,926, IPR 2015-01892, May 26, 2016, on behalf of Symantec Corp.; (2) *Symantec Corp. v. Finjan, Inc.*, 14-cv-299-HSG (N.D. Cal.), on behalf of Symantec Corp., September 14, 2017; (3) one deposition for ten matters: *Intellectual Ventures I LLC v. AT&T Mobility LLC*; AT&T Mobility II LLC, New Cingular Wireless Services, Inc., SBC Internet Services, Inc., Wayport, Inc., and Cricket Wireless LLC, C.A. No. 12-193 (LPS); *Intellectual Ventures II LLC v. AT&T Mobility LLC*; AT&T Mobility II LLC, New Cingular Wireless Services, Inc., SBC Internet Services, Inc., Wayport, Inc., and Cricket Wireless LLC, C.A. No. 13-1631 (LPS); *Intellectual Ventures I LLC v. T-Mobile USA, Inc. and T-Mobile US, Inc.*, C.A. No. 13-1632 (LPS); *Intellectual Ventures II LLC v. T-Mobile USA, Inc.*

and T-Mobile US, Inc., C.A. No. 13-1633 (LPS); *Intellectual Ventures I LLC*, v. *Nextel Operations, Inc.*, *Sprint Spectrum L.P.*, *Boost Mobile, LLC* and *Virgin Mobile USA, L.P.*, C.A. No. 13-1634 (LPS); *Intellectual Ventures II LLC* v. *Nextel Operations, Inc.*, *Sprint Spectrum L.P.*, *Boost Mobile, LLC* and *Virgin Mobile USA, L.P.*, C.A. No. 13-1635 (LPS); *Intellectual Ventures I LLC*, v. *United States Cellular Corporation*, C.A. No. 13-1636 (LPS); *Intellectual Ventures I LLC* v. *United States Cellular Corporation*, C.A. No. 13-1637 (LPS); *Intellectual Ventures II LLC* v. *AT&T Mobility LLC*, *AT&T Mobility II LLC*, *New Cingular Wireless Services, Inc.*, C.A. No. 15-799 (LPS); *Intellectual Ventures I LLC* v. *T-Mobile USA, Inc. and T-Mobile US, Inc.*, C.A. No. 15-800 (LPS), on behalf of AT&T Mobility LLC; AT&T Mobility II LLC, Boost Mobile, LLC Cricket Wireless LLC, Nextel Operations, Inc., New Cingular Wireless Services, Inc., SBC Internet Services, Inc., Sprint Spectrum L.P., T-Mobile USA, Inc., T-Mobile US, Inc., United States Cellular Corporation Virgin Mobile USA, L.P., and Wayport, Inc., November 15, 2016; (4) *Hitachi Maxell, LTD.*, v. *Top Victory Electronics (Taiwan) Co. Ltd., et al.*, 2:14-cv-1121 JRG-RSP (E.D. Texas), on behalf of Top Victory Electronics (Taiwan) Co. LTD, *et. al.*, January 20, 2016; (5) *Sprint Spectrum, L.P.* v. *General Access Solutions, Ltd.*, Petition for *Inter Partes Review* of U.S. Patent No. 7,173,916, IPR 2017-01885, on behalf of Sprint Spectrum L.P.,

July 13, 2018; (6) *Nichia Corporation v. Vizio, Inc.*, 8:16-cv-00545; on behalf of Vizio, Inc., October 12, 2018; (7) *Intellectual Ventures I LLC, v. T-Mobile USA, Inc., T-Mobile US, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson*, 2:17-cv-00557 (JRG), on behalf of T-Mobile USA, Inc., T-Mobile US, Inc., Ericsson Inc., and Telefonaktiebolaget LM Ericsson, October 19, 2018; (8) *Pfizer, Inc. v. Biogen, Inc.*, Petition for *Inter Partes Review* of U.S. Patent No. 8,821,873, IPR 2017-01168, on behalf of Pfizer, November 3, 2018; (9) *Finjan, Inc. v. ESET, LLC and ESET SPOL. S.R.O.*, 3:17-cv-00183-CAB-BGS, on behalf of ESET, January 15, 2019; (10) *Finjan, Inc. v. Cisco Systems, Inc.*, 5:17-cv-00072-BLF-SVK, on behalf of Cisco Systems, Inc., September 6, 2019; (11) *Facebook, Inc., Instagram, LLC and Whatsapp Inc. v. Blackberry Limited for Inter Partes Review* of U.S. Patent No. 9,349,120 B2, on behalf of Facebook, Inc., Instagram, LLC and Whatsapp Inc., December 20, 2019; (12) *3Shape A/S and 3Shape Inc. v. Align Technology, Inc.*, Petition for *Inter Partes Review* of U.S. Patent No. 7,156,661, IPR 2020-00222 and IPR 2020-00223, August 10, 2020, on behalf of 3Shape A/S and 3Shape Inc.; (13) *Finjan Inc. v. Rapid7, Inc. and Rapid7 LLC*, District of Delaware, 1:18-cv-01519-MN, September 15, 2020, on behalf of Rapid7 Inc. and Rapid7 LLC; (14) *VLSI Technology LLC v. Intel Corporation*, Western District of Texas, 6:19-cv-00254, 6:19-

cv-00255, 6:19-cv-00256, September 23, 2020, on behalf of the Intel Corporation; (15) *Finjan Inc. v. Sonicwall, Inc.*, Northern District of California, 5:17-cv-04467-BLF-HRL, October 27, 2020, on behalf of Sonicwall, Inc.; (16) *VLSI Technology, LLC v. Intel Corporation*, District of Delaware, 1:18-cv-00966-CFC-CJB, February 5, 2021, on behalf of the Intel Corporation; (17) *Unified Patents, LLC v. 3BCOM, LLC*, Petition for *Inter Partes Review* of U. S. Patent 7,127,210, February 11, 2021, on behalf of Unified Patents; (18) *Finjan, Inc. v. Qualsys, Inc.*, Northern District of California, 4:18-cv-07229-YGR, March 1, 2021, on behalf of Qualsys, Inc.; (19) *Qualcomm, Inc. v. Monterey Research LLC*, Petition for *Inter Partes Review* of U. S. Patent 6,534,805, May 6, 2021, on behalf of Qualcomm, Inc.; (20) *Hulu, LLC v. Sound View Innovations, LLC*, Petition for *Inter Partes Review* of U. S. Patent 5,806,062, May 14, 2021, on behalf of Hulu, LLC; and, (21) *VLSI Technology LLC v. Intel Corporation*, Western District of Texas, 6:19-cv-00254, 6:19-cv-00255 and 6:19-cv-00256, August 3, 2021, on behalf of Intel Corporation; (22) *Liquidia Technologies, Inc. v. United Therapeutics Corporation*, Petition for *Inter Partes Review* of U. S. Patent 10,716,793 B2, October 20, 2021, on behalf of Liquidia Technologies, Inc.; (23) *EcoFactor, Inc. v. Google, Inc.*, Western District of Texas, 6:20-cv-00075 (ADA), 6:20-0078-ADA, and 6:20-cv-00080 ADA, October 27, 2021, on

behalf of Google, Inc.; (24) *Liquidia Technologies, Inc. v. United Therapeutics Corporation*, Petition for *Inter Partes Review* of U. S. Patent 10,716,793 B2, March 11, 2022, on behalf of Liquidia Technologies, Inc.; (25) *Juniper Networks, Inc. v. Swarm Technology LLC*, Petition for *Inter Partes Review* of U. S. Patent 9,852,004, May 5, 2022, on behalf of Juniper Networks, Inc.; and, (26) *ParkerVision, Inc. v. Intel Corporation*, Western District of Texas, 6:20-cv-108 (ADA), October 26, 2022, on behalf of the Intel Corporation.

10. My full *curriculum vitae* is attached hereto as Appendix A.

III. PRELIMINARIES

A. Scope of This Declaration

11. I am not an attorney and will not offer opinions on the law. I am, however, rendering my expert opinion on the authenticity of the documents referenced herein and on when and how each of these documents was disseminated or otherwise made available to the extent that persons interested and ordinarily skilled in the subject matter or art, exercising reasonable diligence, could have located the documents before February 22, 2012.

12. I am informed by counsel that an item is considered authentic if there is sufficient evidence to support a finding that the item is what it is claimed to be. I am also informed that authenticity can be established based on the contents of the documents themselves, such as the appearance, contents, substance, internal

patterns, or other distinctive characteristics of the item, taken together with all of the circumstances. I am further informed that an item is considered authentic if it is at least 20 years old, in a condition that creates no suspicion of its authenticity, and in a place where, if authentic, it would likely be. Lastly, I have been informed that a document's authenticity can be established by comparison with an authentic specimen.

13. I am informed by counsel that a printed publication qualifies as publicly accessible as of the date it was disseminated or otherwise made available such that a person interested in and ordinarily skilled in the relevant subject matter could locate it through the exercise of ordinary diligence.

14. While I understand that the determination of public accessibility under the foregoing standard rests on a case-by-case analysis of the facts particular to an individual publication, I also understand that a printed publication is rendered "publicly accessible" if it is cataloged and indexed by a library such that a person interested in the relevant subject matter could locate it. That is, I understand that cataloging and indexing by a library is sufficient, although there are other ways that a printed publication may qualify as publicly accessible. One manner of sufficient indexing is indexing according to subject matter category. I understand that the cataloging and indexing by a single library of a single instance of a

particular printed publication is sufficient, even if the single library is in a foreign country. I understand that, even if access to a library is restricted, a printed publication that has been cataloged and indexed therein is publicly accessible so long as a presumption is raised that the portion of the public concerned with the relevant subject matter would know of the printed publication. I also understand that the cataloging and indexing of information that would guide a person interested in the relevant subject matter to the printed publication, such as the cataloging and indexing of an abstract for the printed publication, is sufficient to render the printed publication publicly accessible.

15. I understand that routine business practices, such as general library cataloging and indexing practices, can be used to establish an approximate date on which a printed publication became publicly accessible. I also understand that the indicia on the face of a reference, such as printed dates and stamps, are considered as part of the totality of the evidence.

B. Persons of Ordinary Skill in the Art

16. I am told by counsel that the subject matter of this proceeding relates generally to manufacturing of inorganic alkali chemicals.

17. I have been informed by counsel that a “person of ordinary skill in the art at the time of the inventions” is a hypothetical person who is presumed to be

familiar with the relevant field and its literature at the time of the inventions. This hypothetical person is also a person of ordinary creativity, capable of understanding the scientific principles applicable to the pertinent field.

18. I am told by counsel that persons of ordinary skill in this subject matter or art would have had the equivalent of either (i) a Master of Science in Chemical Engineering, or an equivalent field, or (ii) a Bachelor of Science in Chemical Engineering or an equivalent field as well as two years of experience in the manufacturing or process development of inorganic alkali chemicals. This level of skill is approximate, and more experience would compensate for less formal education, and vice versa.

19. It is my opinion that such a person would have been engaged in research, learning through study, and practice in the field and possibly through formal instruction the bibliographic resources relevant to his or her research. By not later than the late 1990s, such a person would have had access to a vast array of long-established print resources in the field, as well as to a rich set of online resources providing indexing information, abstracts, and full text services for publications relevant to the field of this dispute.

C. Authoritative Databases

20. In preparing this report, I used authoritative databases, such as the OCLC WorldCat, the Library of Congress Online Catalog, the China Academic Library and Information System (CALIS), *IEEE Xplore* database, and the digital repositories *ResearchGate* and *Semantic Scholar*, to confirm citation details of the various publications discussed.

21. *OCLC WorldCat Database*. The OCLC was created “to establish, maintain and operate a computerized library network and to promote the evolution of library use, of libraries themselves, and of librarianship, and to provide processes and products for the benefit of library users and libraries, including such objectives as increasing availability of library resources to individual library patrons and reducing the rate of rise of library per-unit costs, all for the fundamental public purpose of furthering ease of access to and use of the ever-expanding body of worldwide scientific, literary and educational knowledge and information.”¹ Among other services, OCLC and its members are responsible for

¹ Third Article, Amended Articles of Incorporation of OCLC Online Computer Library Center, Incorporated (available at <https://www.oclc.org/content/dam/oclc/membership/articles-of-incorporation.pdf>)

maintaining the WorldCat database,² used by independent and institutional libraries throughout the world.

22. *IEEE Xplore*.³ Librarians in academic, special, and large public libraries are familiar with the *IEEE Xplore* database. In working with undergraduate and graduate students, researchers, scientists, and the public, librarians are intimately familiar with the *IEEE Xplore* database and rely on its content for access to reliable, accurate publications. Established to serve as a database for the IEEE's ebooks, standards, conference papers, technical reports, and journal articles, and related documents dating from 1988 to the present and selectively from 1913 to 1987, *IEEE Xplore* is a scholarly research database that includes 5.7 million documents which is known for its reputable curation and maintenance of documents and publication information. The *IEEE Xplore* database accurately reports dates of publications and events and accurately reports locations of events in accordance with standard practices for major industry journals. Approximately 20,000 new documents are added to *IEEE Xplore* each month. Abstracts are free to access, but access to full text requires a subscription or institutional login.

² <http://www.worldcat.org/>

³ <https://ieeexplore.ieee.org/Xplore/home.jsp>

23. The *IEEE Xplore* requires peer review before publishing content. I have used IEEE publications in print and online for nearly 50 years. Currently I have access to IEEE documents as part of the resources for faculty through the King Library at San José State University. In addition to covering material from the IEEE, the *IEEE Xplore* also covers materials from the Institution of Engineering and Technology. The *IEEE Xplore* digital library provides Web access to more than 5.5-million full-text documents from some of the world's most highly cited publications. Approximately 20,000 new documents are added to *IEEE Xplore* each month. Abstracts are free to access, but access to full text requires a subscription or institutional login.

24. *ResearchGate*.⁴ A European-based social networking site for scientists and researchers to share papers, ask and answer questions, and find collaborators, *ResearchGate* is the largest academic social network in terms of active users, although other services have more registered users. Features available to *ResearchGate* members include following a research interest and the work of other individual participants, a blogging feature for users to write short reviews on peer-reviewed articles, private chat rooms for sharing data, editing documents, or discussing confidential topics, and a research-focused job board. *ResearchGate*

indexes self-published information on user profiles and suggests members to connect with others who have similar interests. Member questions are fielded to others who have identified relevant expertise on their profiles.

25. As of 2021, *ResearchGate* had more than 20 million scientists, with its largest user-bases coming from Europe and North America. Most of *ResearchGate's* users are involved in medicine, biology, engineering, computer science, agricultural sciences, and psychology.

26. *Semantic Scholar*.⁵ A project developed at the Allen Institute for Artificial Intelligence and publicly released in November 2015, *Semantic Scholar* is designed to be an AI-backed search engine for scientific journal articles which uses a combination of machine learning, natural language processing, and machine vision to add a layer of semantic analysis to the traditional methods of citation analysis, and to extract relevant figures, entities, and venues from papers. *Semantic Scholar* is designed to highlight important, influential papers, and to identify the connections between them.

27. As of January 2018, following a 2017 project that added biomedical papers and topic summaries, the *Semantic Scholar* corpus included more than 40

⁴ <https://www.researchgate.net/>

⁵ <https://www.semanticscholar.org>

million papers from computer science and biomedicine. In March 2018, Doug Raymond, who developed machine learning initiatives for the Amazon Alexa platform, was hired to lead the *Semantic Scholar* project. As of August 2019, the number of included papers had grown to more than 173 million after the addition of the Microsoft Academic Graph records, already used by Lens.org.

D. Indexing

28. A researcher may discover material relevant to his or her topic in a variety of ways. One common means of discovery is to search for relevant information in an index of periodical and other publications. Having found relevant material, the researcher will then normally obtain it online, look for it in libraries, or purchase it from the publisher, a bookstore, a document delivery service, or other provider. Sometimes, the date of a document's public accessibility will involve both indexing and library date information. However, date information for indexing entries is often unavailable. This is especially true for online indices.

29. Indexing services use a wide variety of controlled vocabularies to provide subject access and other means of discovering the content of documents. The formats in which these access terms are presented vary from service to service.

30. Before the widespread development of online databases to index articles in journals, magazines, conference papers, and technical reports, libraries

purchased printed volumes of indices. Graduate library school education mandated that students learn about the bibliographic control of disciplines, the prominent indexing volumes, and searching strategies required to use them effectively and efficiently. Half of the courses that I studied in library school were focused on the bibliography and resources in academic disciplines.

31. Librarians consulted with information seekers to verify citations, check availability in union catalogs, printed books catalogs, and the OCLC database, and make formal requests for materials, *e.g.*, books, conference proceedings, journal articles. Requests were transmitted using Telex machines, rudimentary email systems, and the United States Postal Service. During my career, I have performed and supervised staff who handled these resource sharing tasks.

32. Online indexing services commonly provide bibliographic information, abstracts, and full-text copies of the indexed publications, along with a list of the documents cited in the indexed publication. These services also often provide lists of publications that cite a given document. A citation of a document is evidence that the document was publicly available and in use no later than the publication date of the citing document.

IV. LIBRARY CATALOGING PRACTICES

A. Machine-Readable Cataloging (MARC) Standard

33. I am fully familiar with the library cataloging standard known as the MARC standard, which is an industry-wide standard method of storing and organizing library catalog information.⁶ MARC was first developed in the 1960s by the Library of Congress. A MARC-compatible library is one that has a catalog consisting of individual MARC records for each of its items. Today, MARC is the primary communications protocol for the transfer and storage of bibliographic metadata in libraries.⁷

⁶ The full text of the standard is available from the Library of Congress at <http://www.loc.gov/marc/bibliographic/>

⁷ Almost every major library in the world is MARC-compatible. *See, e.g., MARC Frequently Asked Questions (FAQ)*, Library of Congress, <https://www.loc.gov/marc/faq.html> (last visited October 29, 2022) (“MARC is the acronym for Machine-Readable Cataloging. It defines a data format that emerged from a Library of Congress-led initiative that began nearly fifty years ago. It provides the mechanism by which computers exchange, use, and interpret bibliographic information, and its data elements make up the foundation of most library catalogs used today.”). MARC is the ANSI/NISO Z39.2-1994 (reaffirmed 2016) standard for Information Interchange Format.

34. Since at least the early 1970s and continuing to the present day, MARC has been the primary communications protocol for the transfer and storage of bibliographic metadata in libraries.⁸ As explained by the Library of Congress:

You could devise your own method of organizing the bibliographic information, but you would be isolating your library, limiting its options, and creating much more work for yourself. Using the MARC standard prevents duplication of work and allows libraries to better share bibliographic resources. Choosing to use MARC enables libraries to acquire cataloging data that is predictable and reliable. If a library were to develop a “home-grown” system that did not use MARC records, it would not be taking advantage of an industry-wide standard whose primary purpose is to foster communication of information.

Using the MARC standard also enables libraries to make use of commercially available library automation systems to manage library operations. Many systems are available for libraries of all sizes and are designed to work with the MARC format. Systems are maintained and improved by the vendor so that libraries can benefit from the

⁸ A complete history of the development of MARC can be found in *MARC: Its History and Implications* by Henrietta D. Avram (Washington, DC: Library of Congress, 1975) and available online from the Hathi Trust (<https://babel.hathitrust.org/cgi/pt?id=mdp.39015034388556;view=1up;seq=1>; last visited October 29, 2022).

latest advances in computer technology. The MARC standard also allows libraries to replace one system with another with the assurance that their data will still be compatible.

Why Is a MARC Record Necessary? LIBRARY OF CONGRESS,

<http://www.loc.gov/marc/umb/um01to06.html#part2> (last visited October 29, 2022).

35. Thus, almost every major library in the world is MARC-compatible.

See, e.g., *MARC Frequently Asked Questions (FAQ)*, LIBRARY OF CONGRESS,

<https://www.loc.gov/marc/faq.html> (last visited October 29, 2022) (“MARC is the acronym for MACHine-Readable Cataloging. It defines a data format that emerged from a Library of Congress-led initiative that began nearly fifty years ago. It provides the mechanism by which computers exchange, use, and interpret bibliographic information, and its data elements make up the foundation of most library catalogs used today.”). MARC is the ANSI/NISO Z39.2-1994 standard (reaffirmed in 2016) for Information Interchange Format. The full text of the standard is available from the Library of Congress.⁹

36. A MARC record comprises several fields, each of which contains specific data about the work. Each field is identified by a standardized, unique,

⁹ <http://www.loc.gov/marc/bibliographic/>

three-digit code corresponding to the type of data that follow. For example, a work's title is recorded in field 245, the primary author or creator of the work is recorded in field 100, an item's International Standard Book Number ("ISBN") is recorded in field 020, an item's International Standard Serial Number ("ISSN") is recorded in field 022, an item's Library of Congress call number is recorded in field 050, and the publication date is recorded in field 260 under the subfield "c." *Id.*¹⁰ If a work is a periodical, then its publication frequency is recorded in field 310, alternate publication frequency is recorded in field 321, and the publication dates (*e.g.*, the first and last publication) are recorded in field 362, which is also referred to as the enumeration/chronology field.¹¹

37. MARC records also include several fields that include subject matter classification information. An overview of MARC record fields is available

¹⁰ In some MARC records, field 264 is used rather than field 260 to record publication information. See <http://www.loc.gov/marc/bibliographic/bd264.html> (last visited October 29, 2022) ("Information in field 264 is similar to information in field 260 (Publication, Distribution, etc. (Imprint)). Field 264 is useful for cases where the content standard or institutional policies make a distinction between functions").

¹¹ <http://www.loc.gov/marc/bibliographic/bd3xx.html>

through the Library of Congress website.¹² For example, 6XX fields are termed “Subject Access Fields.”¹³ Among these, for example, is the 650 field; this is the “Subject Added Entry – Topical Term” field.¹⁴ The 650 field is a “[s]ubject added entry in which the entry element is a topical term.”¹⁵ These authenticated subject entries “are assigned to a bibliographic record to provide access according to generally accepted thesaurus-building rules (*e.g., Library of Congress Subject Headings* (LCSH), *Medical Subject Headings* (MeSH)).”¹⁶

38. Further, MARC records include call numbers, which themselves indicate a subject and physical location within the library collections. For example, the 050 field is the “Library of Congress Call Number.”¹⁷ A defined portion of the Library of Congress Call Number is the classification number, and “source of the classification number is *Library of Congress Classification* and the *LC Classification-Additions and Changes*.”¹⁸ Thus, included in the 050 field is a

¹² <http://www.loc.gov/marc/bibliographic/>

¹³ <http://www.loc.gov/marc/bibliographic/bd6xx.html>

¹⁴ <http://www.loc.gov/marc/bibliographic/bd650.html>

¹⁵ *Id.*

¹⁶ *Id.*

¹⁷ <http://www.loc.gov/marc/bibliographic/bd050.html>

¹⁸ *Id.*

subject matter classification. Each item in a library has a single classification number. A library selects a classification scheme (*e.g.*, the Library of Congress Classification scheme just described or a similar scheme such as the Dewey Decimal Classification scheme or the National Library of Medicine Classification scheme) and uses it consistently. When the Library of Congress assigns the classification number, it appears as part of the 050 field. If a local library assigns the classification number, it appears in a 090 field. In either scenario, the MARC record includes a classification number that represents a subject matter classification.

39. For MARC records created by libraries other than the Library of Congress (*e.g.*, a university library or a local public library), the classification number may appear in a 09X (*e.g.*, 090) field.¹⁹

40. OCLC provides its members online access to MARC records through its OCLC bibliographic database. When an OCLC member institution acquires a work, it creates a MARC record for this work in its computer catalog system in the ordinary course of its business. MARC records created at the Library of Congress were initially tape-loaded into the OCLC database through a subscription to

¹⁹ <http://www.loc.gov/marc/bibliographic/bd09x.html>

MARC Distribution Services daily or weekly. Once the MARC record is created by a cataloger at an OCLC member institution or tape-loaded from the Library of Congress, the MARC record is then made available to any other OCLC members online, and therefore made available to the public. Accordingly, once the MARC record is created by a cataloger at an OCLC member institution or is tape-loaded from the Library of Congress or another library anywhere in the world, any publication corresponding to the MARC record has been cataloged and indexed according to its subject matter such that a person interested in that subject matter could, with reasonable diligence, locate and access the publication through any library with access to the OCLC bibliographic database or through the Library of Congress.

41. When an OCLC member institution creates a new MARC record, OCLC automatically supplies the date of creation for that record. The date of creation for the MARC record appears in the fixed field (008), characters 00 through 05. The MARC record creation date reflects the date on which, or shortly after which, the item was first acquired or cataloged. Initially, field 005 of the MARC record is automatically populated with the date the MARC record was created in year, month, day format (YYYYMMDD) (some of the newer library catalog systems also include hour, minute, second (HHMMSS)). Thereafter, the

library's computer system may automatically update the date in field 005 every time the library updates the MARC record (*e.g.*, to reflect that an item has been moved to a different shelving location within the library). Field 005 is visible when viewing a MARC record via an appropriate computerized interface, but when a MARC record is printed to hardcopy, no "005" label appears. The initial field 005 date (*i.e.*, the date the MARC record was created) does appear, however, next to the label "Entered."²⁰ The date upon which the most recent update to field 005 occurred also appears, next to the label "Replaced." Thus, when an item's MARC record has been printed to hardcopy—as is the case with the exhibits to this report—the date reflected next to the label "Entered" is necessarily on or after the date the library first cataloged and indexed the underlying item.

42. Once one library has cataloged and indexed a publication by creating a MARC record for that publication, other libraries that receive the publication do not create additional MARC records—the other libraries instead rely on the original MARC record. They may update or revise the MARC record to ensure

²⁰ In this report, I sometimes refer to the "Entered" entry as field 008, characters 00-05. Field 005 is visible when viewing a MARC record via an appropriate computerized interface. But when a MARC record is printed directly to hardcopy

accuracy, but they do not replace or duplicate it. This practice does more than save libraries from duplicating labor, it also enhances the accuracy of MARC records. It also allows librarians around the world to know that a particular MARC record is authoritative. In contrast, a hypothetical system wherein duplicative records were created would result in confusion as to which record is authoritative.

43. The date of creation of the MARC record by a cataloger at an OCLC member institution reflects when the underlying item is accessible to the public. Upwards of two-thirds to three-quarters of book sales to libraries come from a jobber or wholesaler for online and print resources. These resellers make it their business to provide books to their customers as fast as possible, often providing turnaround times of only a single day after publication. Libraries purchase a significant portion of the balance of their books directly from publishers themselves, which provide delivery on a similarly expedited schedule. In general, libraries make these purchases throughout the year as the books are published and shelve the books as soon thereafter as possible in order to make the books available to their patrons. Thus, books are generally available at libraries across the country within just a few days of publication.

from the OCLC database, the “005” label is not shown. The date in the 005 field instead appears next to the label “Replaced.”

V. PUBLICATIONS

A. Fu book chapter [Exhibit 1003]

44. Attached hereto as Exhibit 1003 is a copy of an excerpt from the book titled *Practical Inorganic Chemical Technology* edited by Dexue Fu, Changchun Liu, Jingcheng Tian, Longdao Wang, and Zhansheng Cheng (hereafter “Fu”) and issued by Xi’an Jiaotong University Press with an August 1999 copyright date. The excerpt is Chapter 7, Section 7.2, “Soda Ash Industry: Preparation of Soda Ash by Ammonia Soda Process.” Exhibit 1003 is a true and correct copy of the title page, copyright page, table of contents, and Fu chapter in Chinese (pages 254-284), which was obtained from Tsinghua University Library under my instruction. The text in Exhibit 1003 is complete; no pages are missing, and the text on each page appears to flow seamlessly from one page to the next; further, there are no visible alterations to the document. Exhibit 1003 is a true and correct copy in a condition that creates no suspicion about its authenticity. Attachment 1a is the English translation of Exhibit 1003. The English translation includes the title page, copyright page, table of contents, and Fu chapter.

45. Attached hereto as Attachment 1b is a true and correct copy of the metadata record for this book from the Tsinghua University Library online catalog. The library ownership is indicated by the presence of the library’s name at the bottom of the screen. The Tsinghua University Library uses the ALMA integrated

library system,²¹ a product of Clarivate,TM “a global leader in providing trusted insights and analytics to accelerate the pace of innovation.”²² The book is identified by title, author, subjects, creation (publication) date, language (Chinese), and ISBN (7-5605-1169-4). I personally identified and retrieved the library catalog record which is Attachment 1b.

46. Based on finding a copy of the Fu book in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 1b, it is my opinion that the book titled *Practical Inorganic Chemical Technology* was publicly available on or shortly after August 31, 1999, as shown in the creation date field.

47. Attached hereto as Attachment 1c is a true and correct copy of the MARC record for the book titled *Practical Inorganic Chemical Technology* obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 1c. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 1c, that library code is “CALIS,” which means that the MARC record

²¹ <https://exlibrisgroup.com/products/alma-library-services-platform/>

²² <https://clarivate.com/about-us/>

for this book was created at the China Academic Library and Information System Office (Peking, China).

48. As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the China Academic Library and Information System Office created OCLC record number 768918563 on April 29, 2000, as shown in the “Entered” field (“20000429”). The ISBN on Exhibit 1003 (7-5605-1169-4) matches the ISBN in field 020 of Attachment 1c. Therefore, the book is the same one that the cataloger used to create Attachment 1b in the China Academic Library and Information System Office. The library continues to update and enhance this MARC record to meet current cataloging rules. The most recent enhancement to Attachment 1c occurred on October 10, 2015, as shown in the “Replaced” field (“20151015”). I personally identified and retrieved the MARC record that is Attachment 1c.

49. Further, as of April 29, 2000, the MARC record attached hereto as Attachment 1c was accessible through any library with access to the OCLC bibliographic database, which means that the corresponding publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

50. *WorldCat*, the public view of the OCLC bibliographic database, indicates that the MARC record for the book titled *Practical Inorganic Chemical Technology* as cataloged at the China Academic Library and Information System Office is currently available from 2 libraries.²³ Based on finding a copy of Exhibit 1003 in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 1a, it is my opinion that the Fu book titled *Practical Inorganic Chemical Technology* was publicly available on or shortly after April 29, 2000.

B. Xi book [Exhibit 1004]

51. Attached hereto as Exhibit 1004 is a copy of excerpts from the two-volume book titled *Waste-Free Technological Processes* by Xi Deli (hereafter “Xi”) issued by Tsinghua University Press with a February 1990 copyright date. The excerpt is a selection from the paper titled “Sodium Carbonate” (page 225). Exhibit 1004 is a true and correct copy of the title page, copyright page, table of contents, and text in Chinese (page 225), which was obtained from Tsinghua University Library under my instruction. The text in Exhibit 1004 is complete; there are no visible alterations to the document. Exhibit 1004 is a true and correct copy in a condition that creates no suspicion about its authenticity. Attachment 2a

²³ <https://www.worldcat.org/title/768918563>

is the English translation of the excerpts from Exhibit 1004. The English translation includes the title page, copyright page, table of contents, and chapter excerpts.

52. Attached hereto as Attachment 2b is a true and correct copy of the metadata record for this book from the Tsinghua University Library online catalog. The library ownership is indicated by the presence of the library's name at the bottom of the screen. The Tsinghua University Library uses the ALMA integrated library system,²⁴ a product of Clarivate,TM “a global leader in providing trusted insights and analytics to accelerate the pace of innovation.”²⁵ The book is identified by title, language (Chinese), and ISBN (7-302-00507-9). I personally identified and retrieved the library catalog record which is Attachment 2b.

53. Based on finding a copy of the Xi book in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 2b, it is my opinion that the two-volume book titled *Waste-Free Technological Processes* was publicly available on or shortly after February 28, 1990, as shown on the copyright page of Exhibit 1004.

²⁴ <https://exlibrisgroup.com/products/alma-library-services-platform/>

²⁵ <https://clarivate.com/about-us/>

54. Attached hereto as Attachment 2c is a true and correct copy of the MARC record for the two-volume book titled *Waste-Free Technological Processes* obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 2c. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 2c, that library code is “N5L,” which means that the MARC record for this book was created at the National Library of China (Beijing, China).

55. As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the National Library of China created OCLC record number 299298501 on July 20, 1992, as shown in the “Entered” field (“19920720”). The ISBN on Exhibit 1004 (7-15063-3415) matches the ISBN in field 020 of Attachment 2c. Therefore, the book is the same one that the cataloger used to create Attachment 2b in the National Library of China. The library continues to update and enhance this MARC record to meet current cataloging rules. The most recent enhancement to Attachment 2c occurred on August 21, 2018, as shown in the “Replaced” field (“20180821”). I personally identified and retrieved the MARC record that is Attachment 2c.

56. Further, as of July 20, 1992, the MARC record attached hereto as Attachment 2c was accessible through any library with access to the OCLC

bibliographic database, which means that the corresponding publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

57. *WorldCat*, the public view of the OCLC bibliographic database, indicates that the MARC record for the two-volume book titled *Waste-Free Technological Processes* as cataloged at the National Library of China is currently available from 5 libraries.²⁶ Based on finding a copy of Exhibit 1004 in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 2a, it is my opinion that the Xi two-volume book titled *Waste-Free Technological Processes* was publicly available on or shortly after July 20, 1992.

C. Hou book excerpt [Exhibit 1006]

58. Attached hereto as Exhibit 1006 is a copy of an excerpt from the book titled *Selected Works of Hou Debang* selected by Li Zhichuan and edited by Chen Xinwen (hereafter “Hou”) issued by Metallurgy Industrial Press with a 1990 copyright date. The excerpt is a selection from the paper titled “Alkali and Chlorine Products” (pages 162-163). Exhibit 1006 is a true and correct copy of the title page, copyright page, table of contents, and text in Chinese (2 pages), which

²⁶ <https://www.worldcat.org/title/299298501>

was obtained from Tsinghua University Library under my instruction. The text in Exhibit 1006 is complete; no pages are missing, and the text on each page appears to flow seamlessly from one page to the next; further, there are no visible alterations to the document. Exhibit 1006 is a true and correct copy in a condition that creates no suspicion about its authenticity. Attachment 3a is the English translation of the excerpts from Exhibit 1006. The English translation includes the title page, copyright page, table of contents, and chapter excerpt.

59. Attached hereto as Attachment 3b is a true and correct copy of the metadata record for this book from the Tsinghua University Library online catalog. The library ownership is indicated by the presence of the library's name at the bottom of the screen. The Tsinghua University Library uses the ALMA integrated library system,²⁷ a product of Clarivate,TM “a global leader in providing trusted insights and analytics to accelerate the pace of innovation.”²⁸ The book is identified by title, author, series, language (Chinese), and ISBN (7-5024-0751-0). I personally identified and retrieved the library catalog record which is Attachment 3b.

²⁷ <https://exlibrisgroup.com/products/alma-library-services-platform/>

²⁸ <https://clarivate.com/about-us/>

60. Based on finding a copy of the Hou book in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 3b, it is my opinion that the book titled *Selected Works of Hou Debang* was publicly available on or shortly after July 31, 1990, as shown on the copyright page of Exhibit 1006.

61. Attached hereto as Attachment 3c is a true and correct copy of the MARC record for the book titled *Selected Works of Hou Debang* obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 3c. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 3c, that library code is “N5L,” which means that the MARC record for this book was created at the National Library of China (Beijing, China).

62. As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the National Library of China created OCLC record number 299129259 on November 21, 1990, as shown in the “Entered” field (“1901121”). The ISBN on Exhibit 1006 (7-5024-0751-0) matches the ISBN in field 020 of Attachment 3c. Therefore, the book is the same one that the cataloger used to create Attachment 3b in the National Library of China. The library continues to update and enhance this MARC record to meet current cataloging rules. The most

recent enhancement to Attachment 3c occurred on February 4, 2020, as shown in the “Replaced” field (“20200204”). I personally identified and retrieved the MARC record that is Attachment 3c.

63. Further, as of November 21, 1990, the MARC record attached hereto as Attachment 3c was accessible through any library with access to the OCLC bibliographic database, which means that the corresponding publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

64. *WorldCat*, the public view of the OCLC bibliographic database, indicates that the book titled *Selected Works of Hou Debang* as cataloged at the National Library of China is currently available from 6 libraries.²⁹ Based on finding a copy of Exhibit 1006 in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 3a, it is my opinion that the Hou book titled *Selected Works of Hou Debang* was publicly available on or shortly after November 21, 1990.

D. Dalian book [Exhibit 1008]

65. Attached hereto as Exhibit 1008 is a copy of an excerpt from the two-volume book titled *Soda Technology*, 2nd edition, compiled by the Dalian Research

²⁹ <https://www.worldcat.org/title/299129259>

& Design Institute of Chemical Industry (hereafter “Dalian”) issued by Chemical Industry Press with a 2004 copyright date. The excerpt is a selection from Chapter 16, “Three Wastes in Production Process Based on Ammonia-Soda Process and Their Treatment and Comprehensive Utilization: Section III: Comprehensive Utilization of Wastes to Produce Chemical Products” (volume 1, pages 402-406). Exhibit 1008 is a true and correct copy of the title page, copyright page, table of contents, and text in Chinese (pages 402-406), which was obtained from Tsinghua University Library under my instruction. The text in Exhibit 1008 is complete; no pages are missing, and the text on each page appears to flow seamlessly from one page to the next; further, there are no visible alterations to the document. Exhibit 1008 is a true and correct copy in a condition that creates no suspicion about its authenticity. Attachment 4a is the English translation of the excerpts from Exhibit 1008. The English translation includes the title page, copyright page, table of contents, and chapter excerpt.

66. Attached hereto as Attachment 4b is a true and correct copy of the metadata record for this book from the Tsinghua University Library online catalog. The library ownership is indicated by the presence of the library’s name at the bottom of the screen. The Tsinghua University Library uses the ALMA integrated

library system,³⁰ a product of Clarivate,TM “a global leader in providing trusted insights and analytics to accelerate the pace of innovation.”³¹ The book is identified by title, author, series, language (Chinese), and ISBN (7-5022-5088-7). I personally identified and retrieved the library catalog record which is Attachment 4b.

67. Based on finding a copy of the Dalian two-volume book in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 4b, it is my opinion that the two-volume book titled *Soda Technology*, 2nd edition, was publicly available on or shortly after April 30, 2004, as shown on the copyright page of Exhibit 1008.

68. Attached hereto as Attachment 4c is a true and correct copy of the MARC record for the two-volume book titled *Soda Technology*, 2nd edition, obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 4c. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 4c, that library code is “T3U,” which means that the MARC record for this book was created at the Tsinghua University Library (Peking, China).

³⁰ <https://exlibrisgroup.com/products/alma-library-services-platform/>

³¹ <https://clarivate.com/about-us/>

69. As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the Tsinghua University Library created OCLC record number 57336601 on December 27, 2004, as shown in the “Entered” field (“20041227”). The ISBN on Exhibit 1008 (7-5025-5088-7) matches the ISBN in field 020 of Attachment 4c. Therefore, the book is the same one that the cataloger used to create Attachment 4b in the Tsinghua University Library. The library continues to update and enhance this MARC record to meet current cataloging rules. The most recent enhancement to Attachment 4c occurred on July 2, 2022, as shown in the “Replaced” field (“20220702”). I personally identified and retrieved the MARC record that is Attachment 4c.

70. Further, as of December 27, 2004, the MARC record attached hereto as Attachment 4c was accessible through any library with access to the OCLC bibliographic database, which means that the corresponding publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

71. *WorldCat*, the public view of the OCLC bibliographic database, indicates that the two-volume book titled *Soda Technology*, 2nd edition, as cataloged at the Tsinghua University Library is currently available from 4

libraries.³² Based on finding a copy of Exhibit 1008 in the Tsinghua University Library and metadata record in its online library catalog attached as Attachment 4a, it is my opinion that the Dalian two-volume book titled *Soda Technology*, 2nd edition, was publicly available on or shortly after December 27, 2004.

VI. SUMMARY OF OPINIONS

72. In view of the foregoing, it is my opinion that the publications described above were publicly available no later than the corresponding date listed in the table below:

Doc.	Publication	Publicly Available No Later Than
Exhibit 1003	Chapter 7, “Soda Ash Industry: Preparation of Soda Ash by ammonia soda Process” (pp. 254-284). <i>Practical Inorganic Chemical Technology</i> , edited by Dexue Fu, Changchun Liu, Jingcheng Tian, Longdao Wang, and Zhansheng Cheng. Xi'an, Shaanxi, China: Xi'an Jiaotong University Press, 1999.	April 29, 2000
Exhibit 1004	Xi de li., <i>Waste-Free Technological Processes</i> . (pp. 225) 2 vols. Beijing, China: Tsinghua University Press, 1990.	July 20, 1992
Exhibit 1006	Hou de bang xuan ji. “Alkali and Chlorine Products” (pp. 162-163). Selected Works of Hou Debang. Selected by Li Zhichuan; edited by Chen Xinwen. Beijing, China: Metallurgy Industrial Press, 1990.	November 21, 1990

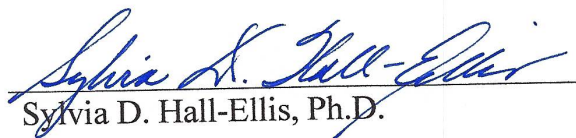
³² <https://www.worldcat.org/title/57336601>

Doc.	Publication	Publicly Available No Later Than
Exhibit 1008	Chapter 16, “Three Wastes in Production Process Based on Ammonia-Soda Process and Their Treatment and Comprehensive Utilization: Section III: Comprehensive Utilization of Wastes to Produce Chemical Products” (vol. 1, pp. 402-406). <i>Soda Technology</i> . 2nd ed. 2 vols. Compiled by Dalian Research & Design Institute of Chemical Industry. Beijing, China: Chemical Industry Press, 2004.	December 27, 2004

73. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

74. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

December 5, 2022


Sylvia D. Hall-Ellis, Ph.D.

Appendix A

CURRICULUM VITAE SYLVIA D. HALL-ELLIS

EDUCATION

Ph.D., University of Pittsburgh, Pittsburgh, Pennsylvania, 1985
M.P.S., University of Denver, Denver, Colorado, 2014
Post Graduate Studies, University of Texas – San Antonio, Texas, 1975-1976
M.L.S., University of North Texas, Denton, Texas, 1972 B.A.,
Rockford University, Rockford, Illinois, 1971

PROFESSIONAL EXPERIENCE

- 1981-** **Consultant for higher education, non-profit organizations, and corporations.**
- 2002-** **Adjunct Professor, School of Information, San José State University, San José, California.** Serve as part-time faculty member teaching graduate students in technical services (cataloging, bibliographic control, classification), “core courses,” and special topics.
- 2014-2016** **Director, Grants and Resource Development, Colorado Community College System.**
Provided leadership and vision to foster the continued growth of rigorous scholarship, innovative projects, and creative work for statewide system, 13 campuses, and 50 teaching sites serving 155,000 students. Responsible for leadership and ensured efficient functioning of contract and grants in compliance with state & federal requirements and successful implementation and management. Served as a subject matter expert and liaison for college Grant Directors for all issues relating to grants and subcontracts.
- 2010-2014** **Senior Grant Administrator, Morgridge College of Education, University of Denver (Colorado).** Provided leadership and vision to foster continued growth of rigorous scholarship, innovative research, and creative work in the Morgridge College of Education. Ensure that contract and grants processes function effectively and efficiently for 60 faculty and researchers with a focus on the successful progression and efficient management of grants totaling \$13M. Worked effectively and collegially with Department Chairs and Program Coordinators on operational grant-related management activities and with a broad range of internal and external constituencies. Supported the dissemination and promotion of faculty research and scholarship to outside constituents at conferences and through publications. Assisted Principal Investigators and grant project teams by coaching, mentoring, and financial management.
- 2011-2013** **Interim Director & Assistant Dean, Westminster Law Library, Sturm College of Law, University of Denver.** Planned, organized, and directed all administrative activities for the library serving students, faculty, and alumni; oversaw the employment, retention, promotion, transfer and termination of library personnel; represented the library at professional conferences and public meetings; created and promoted a climate and culture of acceptance for new programs and services, a positive high-quality image of the law library, and that reflect the organization’s values, encourage excellent performance, and reward high productivity and innovation; provided leadership and set strategic direction of the organization; ensured that the library provided excellent customer service through solution-oriented staff response to patron needs and by responsiveness and continuous improvement of the organization; promoted, developed, and maintained positive working relationships with colleagues and customers including key stakeholders and groups, higher education institutions, the legal community, other regional libraries and districts statewide, and national library organizations.

- 2007-2014** **Associate Professor, Library & Information Science, Morgridge College of Education, University of Denver (Colorado).** Served in leadership role and worked collaboratively in program, college, campus and community environments. Advised and supervised students, taught core and specialized courses at the graduate level in an integrative, student-centered learning environment. Served on LIS, College, and University committees, and maintained working relationships with colleagues in other academic units and information professionals in the Rocky Mountain region and beyond. Served on and chair doctoral student dissertation committees. Oversaw and facilitated the College and LIS graduate student association.
- 2002-2007** **Assistant Professor, Library & Information Science, College of Education, University of Denver (Colorado).** Served as tenure-track faculty member teaching graduate students in “core courses,” resource description and access, service learning, and independent studies. Advised graduate students, participate on LIS and College committees, and serve on doctoral student dissertation committees. Oversaw and facilitated the LIS graduate student association and alumni association.
- 2000-2002** **Affiliate Faculty, Library & Information Science, College of Education, University of Denver (Colorado).** Served as part-time faculty member teaching graduate students in technical services (cataloging, bibliographic control, classification), “core courses,” and special topics. Oversaw and facilitated the LIS graduate student association and alumni association.
- 2000-2001** **Special Assistant to the Secretary’s Regional Representative, U.S. Department of Education, Region VIII, Denver, Colorado.** Served as the principal advisor and representative of the U. S. Secretary of Education’s Regional Representative (SRR). Ensured the implementation of major goals of the SRR and the Secretary. Provided leadership on behalf of the SRR in contacts with high-level officials in Region VIII requiring sensitive policy interpretation in communication with senior Department officials to solve problems and resolve issues raised by State and local education officials. Served as the primary contact for School-to-Work/Career, Children’s Health Insurance Program, and Safe and Drug-Free Schools. Delivered technical assistance to local education agencies and institutions of higher education in technology, professional development, and school construction.
- 1999-2000** **Catalog Librarian, Jefferson County Public Library, Lakewood, Colorado.** Performed original, copy cataloging and classification of library materials (English and Spanish) using standard library protocols; completed original descriptive cataloging and subject analysis; enhanced brief catalog and authority records in III.
- 1997-1999** **Development Officer, McREL International, Aurora, Colorado.** Served as senior member of corporate management team in strategic planning, development of proposals and contracts, implementation, and evaluation of new services, products, and programs for educational agencies. Provided creative leadership to corporate committees to solicit ideas, identify goals and objectives, plan, develop, present, and evaluate professional development opportunities.
- 1995-1997** **Education Specialist, Education Service Center, Region One, Edinburg, Texas.** Served as member of Administrative Cabinet team in strategic planning, development of proposals and contracts, implementation, and evaluation of telecommunications capabilities, services, products, and programs for 40 school districts serving 283,000 students in 7 counties. Provided creative leadership to regional and state committees to solicit ideas, identify strategic goals and objectives, plan, develop, present, and evaluate funding opportunities and professional development for 400 librarians.

- 1993-1996** **Assistant Professor of Library Science, Sam Houston State University, Huntsville, Texas.**
Served as a faculty member teaching 400 graduate students in technical services (cataloging, bibliographic control, classification), automation, and networking. Participated in distance education program and coordinated annual conference. Conducted university and Texas Library Association-funded field research focused on library collection development and academic achievement.
- 1992-1993** **Head Librarian, Rocky Mountain College of Art & Design, Denver, Colorado.**
Responsible for the daily operation, selection and acquisition of materials, formulation of policies for library operations, media center, and photography/slides archives. Designed and implemented library automation and delivery of electronic resources to college community.
- 1981-1985** **Development Officer, PRLC, Inc., Pittsburgh, Pennsylvania.** Served as senior member of corporate management team in strategic planning, development of proposals and contracts, implementation, and evaluation of new services, products, and programs for 100 institutional member organizations. Coordinated the development of proposals and contracts totaling \$4,000,000 annually. Provided creative leadership to corporate committees to solicit ideas, identify goals and objectives, plan, develop, present, and evaluate professional development opportunities.
- 1981** **Director of Library Development, Pennsylvania Department of Education, Harrisburg, Pennsylvania.** Responsible for statewide development, technical assistance, professional development, resource sharing, children's services, institutional library services, networking, and state aid program for all libraries throughout the Commonwealth. Functioned as liaison to Governor's Advisory Council, LSCA Advisory Council, District Administrators, private colleges, universities, consortia managers, and network directors. Supervised \$14,000,000 formula-based state aid program and \$3,000,000 grant awards to individual libraries, consortia, and networks.
- 1978-1981** **Assistant Director, Southern Tier Library System, Corning, New York.** Coordinated operation of system-wide programs (technical assistance, professional development, resource sharing, technical services, outreach) to 40 public libraries in 5 counties serving 500,000 residents. Solicited ideas, identified goals, sponsored, and evaluated professional development opportunities and technical assistance sessions.
- 1976-1978** **Division Librarian for Technical Services, Corpus Christi Public Libraries, Corpus Christi, Texas.** Provided leadership in acquisitions, cataloging, serials control, and processing for main library and 4 branches serving 250,000 residents. Participated as senior member of library management team. Compiled and prepared technical evaluations, reports, and statistical analyses of Division operations to measure the achievement and cost of annual goals, objectives, and staff performance.
- 1975-1976** **System Coordinator, San Antonio Major Resource Center, San Antonio, Texas.** Served as senior member of the management team for District X Office, charged to provide technical assistance, resource sharing, media services, and professional development to librarians and staff representing 30 public library jurisdictions in 21 counties serving 1,500,000 residents. Functioned as liaison to System Director, staff, and members of governing bodies with the System Board of Directors and the Texas State Library and Historical Commission. Prepared LSCA grant applications and monitored awards totaling \$1,100,000 annually.

- 1973-1975** **Bilingual Branch Librarian, San Antonio Public Library, San Antonio, Texas.** Worked as librarian providing reference, information, and readers' advisory services in branch serving 50,000 Spanish-speaking residents in southwest San Antonio. Participated in collection development and resource acquisition activities, specializing in children's work, Spanish language resources, and multicultural studies.
- 1972-1973** **Librarian, Holding Institute, Laredo, Texas.** Worked as high school librarian serving 500 boarding students in Spanish-speaking environment of private school. Provided reference, research assistance, and library instruction to students and 35 faculty members.
- 1966-1971** **Rockford Public Library, Rockford, Illinois.** Worked in branches as part-time as a Library Assistant, Clerk, and Page in city library serving 150,000 residents.

PUBLICATIONS

Editor-reviewed Monographs (Completed and in Progress)

- Hall-Ellis, Sylvia D., and Mary Beth Weber. *Contemporary Cataloging in an RDA Environment: A Handbook for Students and Practitioners*. Chicago, IL: American Library Association. Under contract & In development.
- RDA Testing: Lessons Learned and Challenges Revealed*. Sylvia D. Hall-Ellis and Robert O. Ellett, Jr., eds. Binghamton, N.Y.: Haworth, 2012. 128 p.
- Hall-Ellis, Sylvia D., Stacey L. Bowers, Christopher D. Hudson, and M. Claire Williamson. *Librarian's Handbook for Seeking, Writing, and Managing Grants*. Santa Barbara, Calif.: Libraries Unlimited, 2011. 315 p.
- Hall-Ellis, Sylvia D., with Ann Jerabek, and Merrie W. Valliant. *Contemporary Cataloging: A Handbook for Practitioners and Students*. Open access text. Athens, GA: University of Georgia System Regents, 2011. 767 p.
- Grealy, Deborah S. and Sylvia D. Hall-Ellis. *From Research to Practice: The Scholarship of Teaching and Learning in LIS Education*. Westport, Conn.: Libraries Unlimited, 2009. 175 p.
- Hall-Ellis, Sylvia D. with J. Ann Jerabek. *Grants for School Libraries*. Westport, Conn.: Libraries Unlimited, 2003. 197 p.
- Hall-Ellis, Sylvia D., Doris Meyer, Frank W. Hoffmann, with J. Ann Jerabek. *Grant Writing for Small Libraries and School Library Media Centers*. Boulder, Colo.: NetLibrary, 2001. 173 p.
- Hall-Ellis, Sylvia D., Doris Meyer, Frank W. Hoffmann, with J. Ann Jerabek. *Grant Writing for Small Libraries and School Library Media Centers*. Englewood, Colo.: Libraries Unlimited, 2000. 173 p.

Editor-reviewed Chapters (Completed and In Progress)

- Hall-Ellis, Sylvia D. "Prepared to Lead: Talent, Skills, and Competencies." In *Telling the Technical Services Story*. Chicago, IL: American Library Association, 2020. In development and review.
- Hall-Ellis, Sylvia D. "Grant Writing and Sponsored Research Funding for Academic Librarians." In *The New Librarianship*. Vol. 4. Bradford Lee Eden, ed. New York: Scarecrow Press, 2015. (pp. 163-174)
- Hall-Ellis, Sylvia D. "Organizing Information: Technical Services." In *Information Services Today: An Introduction*. Sandra Hirsch, ed. Lanham, Md.: Rowman and Littlefield, 2015. (pp. 139-148)
- Hall-Ellis, Sylvia D. "Metadata, MARC, and More." In *Rethinking Technical Services, Considering Our Profession and Ourselves: What's the Future of Our Profession?* Mary Beth Weber, ed. Lanham, Md.: Rowman and Littlefield, 2015. (pp. 29-55)
- Hall-Ellis, Sylvia D., ed. "Contingent Faculty: Non-Tenure Track Faculty Series." In the *Faculty Personnel Guidelines Relating to Appointment, Promotion, and Tenure*. November 2011. Denver, Colo.: University of Denver, 2011. 42 p.
- Hall-Ellis, Sylvia D., ed. "Standard VII: Information Resources." In the *Sturm College of Law Self-Study Presentation for Accreditation by the American Bar Association*. Denver, Colo.: University of Denver, Sturm College of Law, 2011. 20 p.

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NATIONAL SERVICE & PROFESSIONAL AFFILIATIONS

American Library Association, Life Member

Association for Library Collections & Technical Services (now CORE)
Cataloging, Classification, and Metadata Section
ALCTS Editorial Board, Member, 2015-2019
Committee on Cataloging: Description and Access, Member, 2008-2012
Test Site for RDA, Manager, 2009-2011
Nominating Committee, Member, 2007-2008
Committee for Education and Training of Catalogers, Chair, 2006-2007, Member, 2003-2007
Competencies & Education for a Career in Cataloging Interest Group, Chair, 2010-2012; Member, 2010-
President's Program Committee, 2015-2016
Education Committee, Member, 2005-2007
Task Force on Competencies and Education for a Career in Cataloging, Chair, 2007-2009
2007 Annual Meeting Pre-conference, "What They Don't Teach in Library School: Competencies,
Education and Employer Expectations for a Career in Cataloging," Steering Committee Chair
Fundraising Committee, Member, 2004-2006
Office of Diversity
Committee on Diversity, Chair, 2010-2011
Diversity Research Advisory Committee, Member, 2009-2010
Spectrum Scholar Mentor, 2009
Diversity Grants Review Committee, Member, 2007, 2010, 2012
Office of Statistics and Research
Research and Statistics Committee, Member, 2005-2007; Intern, 2003-2005
Library Research Round Table
Membership Committee, 2019-2021
Board of Directors, Member At-Large, 2009-2012
Member, 2003-
Office of Accreditation
Accreditation Panel Member (training completed 2004)
Accreditation Review Panel Member (training completed 2004)

REFORMA, Life Member

National Board of Directors, 2005-2013
National Fundraising Chair, 2005-2013
National Recruiting and Mentoring Committee, 2008-2010
Colorado Chapter, Secretary, 2004-2005
Colorado Chapter Liaison to National Board of Directors, 2004-2013

American Association of Law Libraries (AALL), Life Member

Online Audiovisual Catalogers Association (OLAC)

American Association of University Women Association for Library and Information Science Education (ALISE)

University of Denver ALISE Representative, 2003-2008; 2010-2011
Membership Advisory Committee, 2007-2010
Technical Services Education Special Interest Group, 2003-
Garfield Doctoral Dissertation Award Reviewer, 2012
Garfield Doctoral Dissertation Scholarship Reviewer, 2014

American Association of University Professors (AAUP), 2006-

American Grant Writers Association, 2014-
 Grant Professionals Institute, 2016-
 National Grants Management Association, 2014-
 Grant Reviewer (National and Regional Team Leader), U.S. Department of Education, 1998-
 Grant Reviewer, Broadband Technologies Opportunity Program, U.S. Department of Commerce, 2009
 Grant Reviewer, Institute of Museum and Library Services, 1998-2000
 Grant Reviewer, Colorado Department of Education, 2014-
 Grant Reviewer, Colorado State Library, 1998-
 Grant Reviewer, American Association of Community Colleges *Working Connections* program, 1999
 Peer Reviewer, *Journal for Library and Information Science Education*, 2005-
 Peer Reviewer, *Journal of Library Metadata*, 2009
 Peer Reviewer, *International Journal of Library and Information Science*, 2011
 Regular Columnist, *The Bottom Line*, 2013-2016
 Book Reviewer, *Library Journal*, 2001
 Book Reviewer, *Criticas*, 2002-2009
 Book Reviewer, *Colorado Libraries*, 2000-2012

REGIONAL SERVICE & PROFESSIONAL AFFILIATIONS

Mountain Plains Library Association

Professional Development Grants Committee, Member, 2005-2006
 Professional Development Policy and Guidelines Sub-committee Chair, 2006

Colorado Association of Libraries

“Student Voices” Column Editor, *Colorado Libraries*, 2005-2006
 Conference Planning Committee, Member, 2002
 Technical Services and Automation Division, Chair, 2002-2003; Member, 2000-
 Academic Libraries Division, Peer Review Conference Papers Committee, Member, 2007-2009
 Education Committee, Member, 1988-1993
 Diverse Populations Committee, Member, 2009-2013

SERVICE TO THE UNIVERSITY OF DENVER

Center for Teaching and Learning Faculty Advisory Board, 2007-2008; 2010-2012
 Center for Community Engagement and Service Learning Advisory Board, 2007-2012
 Faculty Senate
 Executive Committee, 2008-2013
 Nominations, Rules & Credentials Committee, Chair, 2008-2013; Member 2007-2013
 Appointment, Promotion, and Tenure Revision Committee, 2010-2012
 Grievance Policy Committee Member, 2007-2010
 Law Library Director Search Committee Chair, 2012-2013
 PROF Grant Review, College Representative to the University Review Team, 2006, 2008
 Project Homeless Connect Evaluations, Principal Investigator, 2006-2009
 University Technology Council, 2007-2009
 University of Denver Hyde Interviews for Incoming Freshmen, 2003-2012

SERVICE TO THE MORGRIDGE COLLEGE OF EDUCATION

Appointment, Tenure & Review Committee
 Member, voting, 2003-2005; 2007- 2009
 Chair, Clinical Faculty Promotion & Tenure Policy Subcommittee, 2008-2009
 Member, Community Engagement Subcommittee, 2007-2009
 Member, Tenure Review Panel, 2003

Advancement and Alumni Relations Committee, Chair, 2003-2007; Member, 2002-2007
College Building Committee Member, 2004-2010
College of Education Student Association, Faculty Advisor, 2004-2007; 2009-2010
Faculty Senator, 2007-2013
Research and Scholarship Committee, Chair, 2008-2009; Member, 2002-2003, 2008-2009
Research and Grant Mentoring Committee, Chair, 2009-2010
Research Task Force Member, 2010-2012
Search Committee Member, Assistant Professor for Curriculum & Instruction, 2010-2011
Workload Task Force Member, 2010-2011

SERVICE TO THE LIBRARY & INFORMATION SCIENCE PROGRAM

Library and Information Science Student and Alumni Association, Faculty Advisor, 2002-2008
ALA Student Chapter, Faculty Advisor, 2005-2008
Beta Phi Mu Phi Chapter, Faculty Advisor, 2004-2014
Steering Committee Member, Accreditation by the American Library Association, 2001-2004
Search Committee Member, Associate Professor for LIS, 2006
Search Committee Chair, Assistant Professors for LIS, 2003, 2005, 2006, 2007
Search Committee Ex-Officio Member, Director for LIS, 2004

SERVICE TO SAM HOUSTON STATE UNIVERSITY

Rio Roundup: South Texas Literature Conference, Conference Coordinator, 1993
External Relations, Fund Raising, Grants Committee, Chair, 1993-1995
Advisory Council Committee, Chair, 1993-1995
Students, Admissions, and Advisement Committee, Chair, 1994
Institutional Effectiveness Committee, Member, 1993-1995

SERVICE TO THE COLLEGE OF EDUCATION AND APPLIED SCIENCE

Faculty Affairs Committee, Member, 1993-1995
Curriculum Committee, Member, 1993-1995
Continuing Education Committee, Member, 1993-1995

SERVICE TO THE COMMUNITY

French Teacher & Student Exchange with Laon, France, Monarch High School, Boulder Valley School District (Boulder, Colorado), 2017-
Denver/Boulder Games 2022, Board of Directors, Secretary-Treasurer, 2015-2018
United Way Campaign Committee, College of Education, 2006
Arapahoe County, Election Judge for the County Clerk and Recorder, 2000-2005
Arthritis Foundation, Rocky Mountain Chapter, Certified Educator & Trainer, 1999-2008
Bonfils Blood Center, Silver Level Donor, 2000-2016
Denver Museum of Natural History, Docent, 1992
Tech Prep of the Lower Rio Grande Valley, Inc. (Harlingen, Texas) Board of Directors, 1995-1997
Executive Committee, 1996-1997; Chair, Development Committee, 1995-1997; Chair, Fiscal Agency Committee, 1995-1996; Chair, Colleges and Universities Committee, 1996-1997
Gilpin County (Colorado) Public Library Board of Trustees, 1986-1989; Vice President, 1987-1989
City of Central (Colorado) Economic Development Committee, 1987-1989
Columbine Family Health Centers, Inc. (Nederland and Black Hawk, Colorado) Board of Directors, 1988-1989

CERTIFICATION

Permanent Public Librarian Certificate - Pennsylvania, New York, Texas
Westlaw Expert Witness, 2008-
Certified Grant Writer®, 2016-

AWARDS AND HONORS

Advanced Practitioner for Service Learning and Community Engagement, University of Denver, 2011

Platinum Star Alumnae, College of Information, Library Science & Technologies, University of North Texas, 2009

Commendation for Integration of Technologies in Teaching & Learning Environment, University of Denver, 2006

Outstanding Adjunct Faculty Member Award, College of Education, University of Denver, 2002

Beta Phi Mu, Pi, University of Pittsburgh, 1985

Alpha Lambda Sigma, University of North Texas, 1972

Albert Nelson Marquis Lifetime Achievement Award, Who's Who in America

Who's Who in American Women

Who's Who of Women Executives

Dictionary of International Biography

Who's Who in the East

Who's Who in the South and Southwest

Who's Who in the World

Who's Who of Online Professionals

Who's Who in Library and Information Science

2,000 Notable Women

Who's Who of Emerging Leaders

Who's Who in Professional and Executive Women

Who's Who in American Education

International Who's Who of Professional and Business Women

International Leaders in Achievement

International Educator of the Year

Who's Who in Finance and Industry

Who's Who in Finance and Business

Invited International and National Conference Presentations

- Driscoll, Margaret, Christy Confetti Higgins, Scott Brown, and Sylvia D. Hall-Ellis. *A View from Within: Open House Tour of Three Canvas Core Courses*. Presentation to be delivered at the School of Information, San José State University Professional Development Seminar, San José, California, October 17, 2019.
- Hall-Ellis, Sylvia D. *Invest in Me -- I'm Your Future: Succession Planning for Libraries*. Keynote presentation delivered at the ALCTS President's Symposium, Boston, Mass., January 8, 2016.
- Seidel, Kent E. and Sylvia D. Hall-Ellis. *Making Grants Work for You: Strategies for Doctoral Students and Early Career Scholars*. Presentation delivered at the University Council for Educational Administration, Early Career Scholars Session, Indianapolis, Ind., November 9, 2013.
- Hall-Ellis, Sylvia D. *So You Want to be a Manager; Leadership Skills and Competencies for Technical Services Managers and Administrators*. Presentation delivered at the 138th Annual Conference, American Library Association, Chicago, Ill., June 29, 2013.
- Seidel, Kent E., Karen S. Riley, Lyndsay Agans, Susan Korach, and Sylvia D. Hall-Ellis. *Making Grants Work for You (Instead of Just Working for Grants)*. A panel discussion delivered at the University Council for Educational Administration, Early Career Scholars Session, Denver, Colo., November 17, 2012.
- Hall-Ellis, Sylvia D. *After the Great TS Reorganization: The Westminster Law Library*. Presentation delivered at the 137th Annual Conference, American Library Association, Anaheim, Calif., June 23, 2012.
- Hall-Ellis, Sylvia D. *Conversations with Catalogers in the 21st Century*. A panel discussion sponsored by the ALCTS Competencies for a Career in Cataloging Interest Group, delivered at the 137th Annual Conference, American Library Association, Anaheim, Calif., June 22, 2012.
- Hall-Ellis, Sylvia D., moderator. *Mid-Career Leaders Program*. A panel discussion sponsored by the ALA Committee on Diversity delivered at the 136th Annual Conference, American Library Association, New Orleans, La., June 26, 2011.
- Hall-Ellis, Sylvia D., moderator. *Diversity Town Hall*. A community conversation sponsored by the ALA Committee on Diversity delivered at the 136th Annual Conference, American Library Association, New Orleans, La., June 24, 2011.
- LaBarre, Kathryn, Sylvia D. Hall-Ellis, Karen Anderson, Rick Hasenyager, Christopher Cronin, and Penny Baker. *Briefings from RDA Test Participants*. A panel discussion delivered at the Midwinter Conference, American Library Association, San Diego, Calif., January 7, 2011.
- Miksa, Shawne, Marjorie Bloss, and Sylvia D. Hall-Ellis. *Educating the Next Generation of Catalogers: Teaching RDA*. A panel discussion delivered at the 97th Annual Conference, Association for Library and Information Science Education, San Diego, Calif., January 7, 2011.
- Hall-Ellis, Sylvia D., Robert Maxwell, John Hostage, and George Prager. *RDA Panel: What Cataloging Managers Need to Know*. Presentation delivered at the 103rd Annual Conference, American Association of Law Librarians, Denver, Colo., July 12, 2010.
- Hall-Ellis, Sylvia D. and Stacey L. Bowers. *Catalogers in the RDA Environment: Skill Sets, Expectations and Challenges*. Presentation delivered at the 103rd Annual Conference, American Association of Law Librarians, Denver, Colo., July 11, 2010.

Hall-Ellis, Sylvia D. *Comfortable in Your Cataloging and Metadata Specialist Skin? Or, So You Want to Hire a Cataloger*. Presentation delivered to the ALCTS Research Group at the 134th Annual Conference, American Library Association, Chicago, Ill., July 11, 2009.

Perez, Megan, Sylvia D. Hall-Ellis, and Denise Anthony. *From Novice to Expert: Collaboration for Succession Planning*. A "hot topic" presentation delivered at the 14th ACRL Conference, Seattle, Wash., March 13, 2009.

Hall-Ellis, Sylvia D. *Cataloging in the RDA Environment: Skill Sets, Expectations and Challenges*. Presentation delivered to the ALCTS Research and Publications Committee at the Midwinter Conference, American Library Association, Denver, Colo., January 24, 2009.

Hall-Ellis, Sylvia D. *LIS Cataloging Education for the 21st Century: Expectations and Challenges*. A panel discussion held at the 95th Annual Conference, Association for Library and Information Science Education, Denver, Colo., January 23, 2009.

Chu, Clara, Sylvia D. Hall-Ellis, and Mark Winston. *The Doctoral Degree & Building a Career*. A panel discussion delivered at the ALA Office of Diversity Spectrum Doctoral Fellows E.J. Josey Leadership Institute, Midwinter Conference, American Library Association, Denver, Colo., January 20, 2009.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Fundamentals of Cataloging Course: An Overview of the ALCTS Online Course*. Presentation delivered to the ALCTS Big Heads Group, 133rd Annual Conference, American Library Association, Anaheim, Calif., June 30, 2008.

Hall-Ellis, Sylvia D. *Employers' Expectations for Technical Services Librarians: What We Don't Know*. Presentation delivered to the ALCTS Research and Publications Committee Program, 133rd Annual Conference, American Library Association, Anaheim, Calif., June 28, 2008.

Hall-Ellis, Sylvia D., Virginia R. Maloney, and Mary Stansbury. *Institutional Responses to Engaged Scholarship: The Carnegie Foundation Engaged University Classification at Two Universities*. Presentation delivered to the 94th Annual Conference, Association for Library and Information Science Education, Philadelphia, Pa., January 11, 2008.

Hall-Ellis, Sylvia D. *Puzzles, Problems, and Predicaments*. Presentation delivered to the ALCTS Research Discussion Group, 132nd Annual Conference, American Library Association, Washington, D.C., June 23, 2007.

Hall-Ellis, Sylvia D. *Cataloging Education: A New Emphasis for the Library and Information Science Curriculum*. Presentation delivered to the ALCTS Pre-conference, 132nd Annual Conference, American Library Association, Washington, D.C., June 22, 2007. <http://www.loc.gov/catdir/cpsocareercat.html>

Ellett, Jr., Robert O. and Sylvia D. Hall-Ellis. *Copy Cataloging Done Smarter*. Presentation delivered to the International Conference on Interdisciplinary Information Sciences and Technologies (InSciT2006), October 25-28, 2006.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Cooperative Cataloging: Challenges and Opportunities for Defense Libraries*. Presentation delivered to the 1st Annual Conference of Defense Libraries, Spanish Ministry of Defense, Madrid, Spain, July 7, 2006.

Hall-Ellis, Sylvia D. *Cataloger Competencies: Do the Employers Require What the Professors Teach?* Presentation delivered to the ALCTS CCS Heads of Cataloging Discussion Group, 131st Annual Conference, American Library Association, New Orleans, La., June 26, 2006.

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *From Research to Practice: The Scholarship of Teaching and Learning in LIS Education*. Presentation delivered to the at the 92nd Annual Conference, Association for Library and Information Science Education, San Antonio, Tex., January 18, 2006.

Ellis, Sylvia D. *Employers' Expectations for Entry-Level Catalogers: What Position Announcement Data Indicate*. Research paper delivered to the Technical Services Special Interests Group, 91st Annual Conference, Association for Library and Information Science Education, Boston, Mass., January 12, 2005. <http://dlist.sir.arizona.edu/>

Common Errors in MARC Records Prepared by LIS Students: What Does It Mean? Research paper delivered to the ALCTS CCS Cataloging Norms Discussion Group, Mid-Winter Conference, 90th American Library Association, San Diego, Calif., January 10, 2004.

Hall-Ellis, Sylvia D. *Visual Arts as Foundation for Successful Library Automation: The Rocky Mountain College of Art & Design Experience*. Paper delivered at the 6th Annual Conference of Higher Education, Charleston, S. C., 1993.

Hall, Sylvia D. *Design Elements for Bibliographic Databases: An Overview*. Paper delivered at the 14th Online National Conference, New York, 1983.

Invited Regional Conference Presentations

Hall-Ellis, Sylvia D., Hudson, Christopher D., Brittany Cronin, and Kathryn Michaels. "The Colorado Law Project: Meeting the Public's Need for Legal Information." Panel discussion delivered at the Mountain Plains Library Association Conference, Billings, Mont., April 9, 2011.

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *Education for Information Professionals in New Mexico: Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the New Mexico Library Education Summit, Las Vegas, N.M., September 26, 2005.

Hall-Ellis, Sylvia D. *Public Library-School Library Partnerships*. Presentation delivered at the 3rd Annual Colorado Association of Libraries Conference with the Mountain Plains Library Association, Denver, Colo., October 22, 2004.

Hall-Ellis, Sylvia D. *Learn All You Can – Educational Partnership Opportunities for the Lewis and Clark Bicentennial Commemoration*. Paper delivered at the 3rd Annual Lewis and Clark Bicentennial Council National Planning Conference, Bismarck, N.D., April 26, 1998.

Invited State Conference Presentations

Grealy, Deborah S. and Sylvia D. Hall-Ellis. *Academic Library Leadership Changes: Using Succession Planning and Mentoring*. Presentation delivered at the Minnesota Library Education Conference, St. Cloud, Minn., October 10, 2013.

Hall-Ellis, Sylvia D., Merrie Valliant, and Melissa Powell. *RDA: What Is It and What Do You Need To Do With It At Your Library?* Presentation delivered at the Colorado Library Consortium Spring Conference, Ft. Morgan, Colo., April 26, 2013.

Hall-Ellis, Sylvia D. *Service Learning and the Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 4th LEADS Scholars Orientation, Denver, Colo., August 5, 2009.

Hall-Ellis, Sylvia D. *Service Learning: Enhancement to Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 3rd LEADS Scholars Orientation, Denver, Colo., June 2008.

Hall-Ellis, Sylvia D. *Law Librarianship: A Community Conversation*. Sponsored by the Colorado Association of Law Libraries. Paper delivered at the Colorado Supreme Court Library, Denver, Colo., May 14, 2008.

Hall-Ellis, Sylvia D. *Opportunities and Challenges in Law Librarianship: A Community Conversation*. Presentation delivered at the Sturm College of Law, Denver, Colo., November 7, 2007.

Hall-Ellis, Sylvia D. *Grant Writing Resources for Nursing Professionals*. Presentation delivered at the Presbyterian / St. Luke's Health One Medical Center 1st Annual Research Symposium, Denver, Colo., October 17, 2007.

Project Homeless Connect 4 Event Evaluation – Insights and Lessons Learned. Presentation delivered at the Homelessness Research Symposium: What is DU Doing about Homelessness in Denver, Denver, Colo., September 14, 2007.

Hall-Ellis, Sylvia D. *Service Learning and the Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 2nd LEADS Scholars Orientation, Denver, Colo., August 10, 2007.

Hall-Ellis, Sylvia D. *Education for Information Professionals in a Digital Environment: Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 15th Spring Mountains and Plains Parapros Conference, Denver, Colo., February 24, 2007.

Hall-Ellis, Sylvia D. *Public Library Service to Spanish-Speaking and Latino Residents in Denver: A Case Study*. Presentation delivered at the 4th Annual Colorado Association of Libraries Conference, Denver, Colo., November 10, 2005.

Hall-Ellis, Sylvia D. *Education for Information Professionals in a Digital Environment: Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 14th Annual Mountains and Plains Parapros Conference, Aurora, Colo., July 29, 2005.

Hall-Ellis, Sylvia D. *Educational Opportunities: Library & Information Science Graduate Education at the University of Denver*. Presentation delivered at the 13th Annual Mountains and Plains Parapros Conference, Centennial, Colo., August 6, 2004.

Hall-Ellis, Sylvia D. *Library Education & Training: Focus on the West: An LIS Faculty Member's Personal Response*. Presentation delivered at the 1st Annual Colorado Association of Libraries Conference, Keystone, Colo., October 18, 2002.

Hall-Ellis, Sylvia D. *Grant Writing for School Librarians*. Presentation delivered at the 2002 Annual Colorado Education Media Association Conference, Colorado Springs, Colo., February 15, 2002.

Hall-Ellis, Sylvia D. *Grants – Opportunities for the Future*. Paper delivered at the Southeast Regional Accountability Annual Conference, Lamar, Colo., November 12, 1998.

Hall-Ellis, Sylvia D. *The Texas Library Connection and Interlibrary Loan: An Experiment in Resource Sharing*. Paper delivered at the Texas Computer Educators' Association Annual Conference, Austin, Tex., February 6, 1997.

Hall-Ellis, Sylvia D. *Finding Grant Sources on the Internet: A Guide for Librarians*. Paper delivered at the 2nd Annual Institute for School Library Personnel, Pharr-San Juan-Alamo North High School, Pharr, Tex., July 29, 1996.

Hall-Ellis, Sylvia D. *Mathematical and Logical Thinking: A Critical Intelligence*. Paper delivered at the 3rd Annual Paraprofessional Conference at the University of Texas - Pan American, Edinburg, Tex., March 8, 1996.

Hall-Ellis, Sylvia D. *Cataloging Trends and Issues: Update Session*. Paper delivered at the 1st Annual Institute for School Library Personnel, South Texas Community College, McAllen, Tex., July 19, 1995.

Hall-Ellis, Sylvia D. *Grant Writing: Tips and Encouragement for School Librarians*. Paper delivered at the 1st Annual Institute for School Library Personnel, South Texas Community College, McAllen, Tex., July 18 and 19, 1995.

Hall-Ellis, Sylvia D. *How to Become an Expert Grant Writer*. Paper delivered at the 3rd Annual High School Principals' Academy, South Padre Island, Port Isabel, Tex., June 19, 1995.

Hall-Ellis, Sylvia D. *Texas Library Study: Results from Regions I and II*. Paper delivered at the 3rd Annual Technology Conference, Texas A&M University, College Station, Tex., November 18, 1994.

Hall-Ellis, Sylvia D. *Academic Achievement and Middle School Students*. Paper delivered at the 8th Annual Young Adult Conference, Sam Houston State University, Huntsville, Tex., November 5, 1994.

Hall-Ellis, Sylvia D. *Multimedia Resources for Library Leaders*. Paper delivered at the Institute for Librarians in A Multicultural Environment, Sam Houston State University, Huntsville, Tex., June 10, 1994.

Hall-Ellis, Sylvia D. *Finding the Resource: Empowering the User, or, the Case for Curriculum Based Subject Access to Learning Resource Center Collections*. Paper delivered at the 81st Annual Texas Library Association Conference, Corpus Christi, Tex., April 12-16, 1994.

Hall-Ellis, Sylvia D. and William H. Pichette. *Sam Houston State University Makes Use of OCLC/AMIGOS Collection Analysis CD*. Paper delivered at the 81st Annual Texas Library Association Conference, Corpus Christi, Tex., April 12-16, 1994.

Hall, Sylvia D. *Funding and Library Development in Pennsylvania: A Symbiotic Relationship*. Paper delivered at the Annual Graduate Student Colloquia, University of Pittsburgh, School of Library and Information Science, 1982.

Hall, Sylvia D. *Leadership for Public Library Trustees*. Paper delivered for the Trustees Division, Pennsylvania Library Association Annual Conference, Lancaster, Penn., 1981.

Seminar and Professional Development Presentations

Taylor, Meredith, and Sylvia D. Hall-Ellis. *Talent Management and Succession Planning*. ALCTS eForum, held March 22, 2017.

Hirsh, Sandra, Heather O'Brien, Michelle Holschuh Simmons, Michael Krasulski, and Sylvia D. Hall-Ellis. *Information Services Today: An Introduction. Part 3: Information Services: Roles in the Digital Age*. Rowan and Littlefield in partnership with Library Journal webinar, recorded February 5, 2015.

Hall-Ellis, Sylvia D. and Jennifer Sweda. *Copy Cataloging in an RDA Environment*. ALCTS eForum, held May 14 and 15, 2013.

Hall-Ellis, Sylvia D. *Law Librarianship: A Community Conversation*. Sponsored by the Colorado Association of Law Libraries, presented at the Colorado Supreme Court Library, Denver, Colo., May 14, 2008.

Hall-Ellis, Sylvia D. and Beatrice Z. Gerrish. *Reading and Libraries: Recent Research in Reading*. Presentation at the Ricks Center for Gifted Education, Denver, Colo., March 4, 2008.

Hall-Ellis, Sylvia D. *Cataloger Competencies: Do the Employers Require What the Professors Teach?* Presentation for the School of Library and Information Science, San José State University, February 12, 2008.

Hall-Ellis, Sylvia D. and Robert O. Ellett, Jr. *Cooperative Cataloging: Rules, Tools, and Conventions for Building a Multi-institutional Catalog*. Sponsored for the Spanish Ministry of Defense, Madrid, Spain, July 10, 2006.

Hall-Ellis, Sylvia D. *Cash for Kids: Grant Writing Opportunities for Youth Services Librarians*. Sponsored by the Colorado Young Adult Librarians; presented at Bemis Memorial Library, Littleton, Colo., November 13, 2002.

Hall-Ellis, Sylvia D. *MARC Records and Authority Control: Planning for Bibliographic Database Migration*. Sponsored and held at the Douglas County Public Library, Castle Rock, Colo., May 28, 2002.

Hall-Ellis, Sylvia D. *Grant Writing: A Refresher for Librarians*. Sponsored by Library and Information Science Program, College of Education, University of Denver; presented at University Center at Chaparral, August 12, 2000.

Hall-Ellis, Sylvia D. *Shaking the Money Tree – Basic Grant Writing for Colorado Educators*. Sponsored by the Office of Educational Telecommunications of the Colorado Department of Education.
Pikes Peak Community College, Colorado Springs, Colo., November 16, 1998.
Pueblo School District 60, Pueblo, Colo., November 12, 1998.
University of Northern Colorado, Greeley, Colo., November 10, 1998.
United Technology Educational Partnership, Grand Junction, Colo., November 9, 1998.

Hall-Ellis, Sylvia D. *Cataloging Multimedia, Kits, Globes and Map Materials in USMARC*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 24, 1997 and December 12, 1996.

Hall-Ellis, Sylvia D. *New Standards for School Library Media Centers*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 15, 1997.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future*. Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., April 4, 1997.

Hall-Ellis, Sylvia D. *Cataloging Sound Recordings and Audio Materials in USMARC*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., March 20, 1997 and November 21, 1996.

Hall-Ellis, Sylvia D. *Evaluating and Selecting CD-ROMS for School Library Media Collections*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., March 18, 1997.

Hall-Ellis, Sylvia D. *Cataloging Audiovisual Materials in USMARC*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., February 27, 1997, November 7, 1996 and October 24, 1996.

Hall-Ellis, Sylvia D. *Introduction to Dialog: Basic Searching Strategies*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., February 14, 1997.

Hall-Ellis, Sylvia D. *Cataloging Books in USMARC*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., January 30, 1997, October 10, 1996, September 26, 1996 and August 8, 1996.

Hall-Ellis, Sylvia D. *Advanced Internet Searching Techniques for Librarians*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., January 21, 1997.

Hall-Ellis, Sylvia D. *Texas Library Connection Full-Text Searching*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., December 13, 1996 and October 25, 1996.

Hall-Ellis, Sylvia D. *Developing Evaluation Strategies for Grants and Proposals*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., December 10, 1996.

Hall-Ellis, Sylvia D. *Developing Needs Assessment for Grants and Proposals*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., November 12, 1996.

Hall-Ellis, Sylvia D. *Texas Library Connection Union Catalog Searching*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., November 8, 1996 and September 6, 1996.

- Hall-Ellis, Sylvia D. *Grant Resources on the Internet*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., October 23, 1996.
- Hall-Ellis, Sylvia D. *Preparing a Response to the Telecommunications Infrastructure Fund Board: Needs Assessment, Professional Development Framework, and Evaluation Strategies*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., October 16, 1996.
- Hall-Ellis, Sylvia D. *Texas Library Connection: Building the Districtwide Bibliographic Database*. Sponsored and hosted by Mercedes Independent School District, Mercedes, Tex., September 13, 1996 and August 8, 1996.
- Hall-Ellis, Sylvia D. *Texas Library Connection: Building the Districtwide Bibliographic Database*. Sponsored and hosted by Los Fresnos Consolidated Independent School District, Los Fresnos, Tex., August 12, 1996.
- Hall-Ellis, Sylvia D. *School-to-Work and Special Education: An Inclusive Partnership for Success*. Sponsored and hosted by the Office of Special Education, Region One Education Service Center, Edinburg, Tex., September 11, 1996.
- Hall-Ellis, Sylvia D. *Telecommunications Infrastructure Fund Board: An Overview of Funding for Secondary Schools*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., August 31, 1996.
- Hall-Ellis, Sylvia D. *Cataloging Books, Multimedia, and Realia in USMARC*. Sponsored and hosted by Edinburg Consolidated Independent School District, Edinburg, Tex., August 6, 1996.
- Hall-Ellis, Sylvia D. *Internet Resources for Grant Writers*. Sponsored and hosted by Region One Education Service Center, Edinburg, Tex., April 20, 1996.
- Hall-Ellis, Sylvia D. *Enhanced Grant Writing Skills for Mathematics Educators: Writing Skills for Campus Teams*. Sponsored and hosted by the Office of General Education, Region One Education Service Center, Edinburg, Tex., March 22, 1996.
- Hall-Ellis, Sylvia D. *Internet Resources for Grant Writers*. Sponsored and hosted by the College of Education and Applied Science, Sam Houston State University, Huntsville, Tex., March 9, 1996.
- Hall-Ellis, Sylvia D. *Grant Writing for Mathematics Educators: A Development Process for Campus Teams*. Sponsored and hosted by the Office of General Education, Region One Education Service Center, Edinburg, Tex., March 4, 1996.
- Hall-Ellis, Sylvia D. *Shaking the Money Tree: Preparing Successful Technology Grant Applications*. Sponsored and hosted by the Office of Technology and Media Services, Region One Education Service Center, Edinburg, Tex., February 29, 1996 and April 29, 1996.
- Hall-Ellis, Sylvia D. *District-wide Technology Planning: Technical Assistance for the Texas Education Agency Initiative*. Sponsored and hosted by the Office of Technology and Media, Region One Education Service Center, Edinburg, Tex., February 2, 1996.
- Hall-Ellis, Sylvia D. *Enhanced Grant Writing Skills*. Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., January 27, 1996.
- Hall-Ellis, Sylvia D. *United States Copyright Act of 1976, Video Transmissions, Computer Software and the Internet*. Sponsored and hosted by the Office of Technology and Media, Region One Education Service Center, Edinburg, Tex., January 24, 1996.

Hall-Ellis, Sylvia D. *The Grant Writing Development Process*. Sponsored and hosted by Pharr-San Juan-Alamo Independent School District, Pharr, Tex., January 20, 1996.

Hall-Ellis, Sylvia D. *MARC Cataloging of Materials for Library Media Centers*. Sponsored and hosted by the Office of Media Services, Region One Education Service Center for the Donna Independent School District, Donna, Tex., August 17, 1995.

Hall-Ellis, Sylvia D. *Classification*. Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., May 10, 1995.

Library Technical Services. Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., April 26, 1995.

Hall-Ellis, Sylvia D. *Grant Writing: An Introduction for Public School Administrators*. Sponsored and hosted by the Office of Administrative Services, Region One Education Service Center, Edinburg, Tex., April 19, 1995.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future*. Sponsored and hosted by the United Independent School District, Laredo, Tex., March 31, 1995.

Hall-Ellis, Sylvia D. *Using USMARC*. Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., March 29, 1995.

Hall-Ellis, Sylvia D. *Library Media Center Policies and Guidelines: How to Prepare for School Board Adoption*. Sponsored and hosted by the Office of Technology and Media Services, La Joya Independent School District, La Joya, Tex., March 10, 1995.

Hall-Ellis, Sylvia D. *Developing District-wide Policies and Guidelines for Library Media Centers*. Sponsored and hosted by the Office of Technology and Media Services, La Joya Independent School District, La Joya, Tex., January 10, 1995.

Hall-Ellis, Sylvia D. *MARC Cataloging of Audiovisual Materials for Library Media Centers*. Sponsored and hosted by the Office of Library Media and Technology Services, Cypress-Fairbanks Independent School District, Houston, Tex., December 1, 1994.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future*. Sponsored and hosted by United Independent School District, Laredo, Tex., October 14, 1994.

Hall-Ellis, Sylvia D. *The School Library Media Specialist in the 21st Century: Visions for the Future*. Sponsored and hosted by the Laredo Independent School District, Laredo, Tex., October 7, 1994.

Hall-Ellis, Sylvia D. *MARC Cataloging for Library Media Centers*. Sponsored by the Office of Library Media and Technology Services, Cypress-Fairbanks Independent School District, Houston, Tex., October 5, 1994.

Hall-Ellis, Sylvia D. *Jump to the Head of the Class: Undergraduate Library Resources Available at Sam Houston State University*. Sponsored by the Office of the Associate Vice President for Student Services, Sam Houston State University, Huntsville, Tex., October 4, 1994.

Hall-Ellis, Sylvia D. *CD-ROMs - 1994's Newest and the Best for Secondary Level Media Centers*. Sponsored and hosted by Clear Lake Independent School District, Houston, Tex., June 3, 1994.

Hall-Ellis, Sylvia D. *Introduction to Classification*. Sponsored by AJ Seminars, Rockville, Maryland; presented at Holiday Inn, Market Center, Dallas, Tex., May 18, 1994.

Hall-Ellis, Sylvia D. *Basic Descriptive Cataloging*. Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., May 4, 1994.

Hall-Ellis, Sylvia D. *Shaking the Money Tree - Part II: Writing Successful Grant Applications*. Sponsored by Donna Independent School District, Donna, Texas, and Region One Education Service Center Edinburg, Texas; presented at South Texas Community College Library, McAllen, Tex., April 29, 1994.

Hall-Ellis, Sylvia D. *Using MARC*. Sponsored by AJ Seminars, Rockville, Maryland; presented at Holiday Inn, Market Center, Dallas, Tex., April 6, 1994.

Hall-Ellis, Sylvia D. *Automated Authority Control*. Sponsored by AJ Seminars, Rockville, Maryland; presented at University Hilton Hotel, Houston, Tex., March 23, 1994.

Hall-Ellis, Sylvia D. *Automating the District School Library Media Centers: Choices and Opportunities*. Sponsored and hosted by the Office of Technology and Library Media Services, Fort Bend Independent School District, Sugar Land, Tex., March 4, 1994.

Hall-Ellis, Sylvia D. *Shaking the Money Tree - Part I: Preparing Successful Grant Applications*. Sponsored and hosted by the Office of Library Media Services, Donna Independent School District, Donna, Tex., February 4, 1994.

GRADUATE COURSES TAUGHT

San José State University, School of Library and Information Science

- INFO 249 – Advanced Cataloging and Classification (Fall 2015, 2016; Summer 2016)
- INFO 287 – Special Topics in Cataloging and Classification (Spring 2017, 2018, 2019, 2020, 2021, 2022; Fall 2020, 2021, 2022)
- LIBR 248 – Beginning Cataloging and Classification (Summer 2002, 2003, 2004, 2005, 2006)
- LIBR 249 – Advanced Cataloging and Classification (Summer 2003; Fall 2014; Summer 2015)

University of Denver, Morgridge College of Education

- HED 5991 – Grant Writing in Higher Education (Spring 011)
- LIS 4010 – Organization of Information (Fall 2002, 2003, 2004, 2005, 2006, 2009; Winter 2005; Spring 2004, 2005, 2006)
- LIS 4020 – Professional Principles and Ethics (Summer 2000)
- LIS 4040 – Management of Libraries and Information Centers (Fall 2010; Spring 2003, 2009 (DS); Winter 2005)
- LIS 4070 – Cataloging and Classification (Winter 2008, 2009, 2010, 2011, 2012; Fall 2009 (DS))
- LIS 4321 – Collection Management (Spring 2005)
- LIS 4326 – LIS Research (Winter 2009 (DS); Spring 2009 (DS))
- LIS 4350 – Adult Materials and Services (Summer 2006, 2009)
- LIS 4379 – Social Sciences Resources (Spring 2009)
- LIS 4400 – Cataloging and Classification (Spring 2000, 2001; Winter 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009; Summer 2005, 2006 – course renumbered LIS 4070, September 2007)
- LIS 4401 – Descriptive Cataloging (Winter 2001; Spring 2002, 2003, 2006, 2007, 2008, 2009; Summer 2005)
- LIS 4402 – Subject Cataloging (Spring 2001, 2009; Summer 2005, 2006, 2007, 2008)
- LIS 4403 – Classification Schemes (Fall 2007, 2008, 2009 (DS))
- LIS 4405 – Authority Control (Winter 2009)
- LIS 4510 – Materials and Services for Children (Winter 2004; Summer 2005)
- LIS 4620 – Grant Writing and Fundraising (Summer 2000, 2002, 2004, 2010; Winter 2006; Fall 2006, 2007, 2008, 2009)
- LIS 4700 – Seminar in Technical Services (Fall 2001)
- LIS 4700 – Seminar in Public Libraries (Summer 2002)
- LIS 4804 – Management of Electronic Records (Spring 2004; Fall 2005)
- LIS 4902 – Capstone Projects (Winter 2003, Spring 2008, 2009, 2011)
- LIS 4910 – Independent Study (every quarter Winter 2000 through Spring 2011)
- LIS 4920 – Service Learning (every quarter Summer 2004 through Spring 2011)
- Grant Writing Certificate Seminar for Non-Profit Organizations (Fall 2020, 2021; Spring 2021)
- RMS 4954 – Grant Writing (Summer 2013, 2014)
- RMS 4959 – Content Analysis Methodology (Spring 2015)
- QRM 4978 – Grant Writing (Summer 2011, 2012)

Rutgers University, School of Communication and Information

- SC&I 522 – Cataloging and Classification (Summer 2013)

University of Arizona, College of Behavioral and Social Sciences

- LIS 602 – Cataloging and Classification (Summer 1995)
- LIS 612 – Advanced Online Search and Retrieval (Summer 1995)

Sam Houston State University, College of Education & Applied Science

- LIS 532 - Cataloging and Classification (Fall 1993, 1994, 1995)
- LIS 563 - Advanced Cataloging and Classification (Summer 1994)
- LIS 567 - Research Methods (Spring 1994, Spring 1995)
- LIS 591 - Educational Technology (Spring 1994, 1995)
- LIS 596 - Networking and Computer Technologies in Education (Fall 1993, Summer 1994, Fall 1995)

Dissertations at the University of Denver

Bowers, Stacey L. *Library Anxiety of Law School Students: A Study Utilizing the Multidimensional Library Anxiety Scale*. Chair, May 5, 2010.

Fattor, Melissa M. *Student Engagement Differences by Ethnicity and Scale for Ninth Grade Students*. Chair, November 1, 2010.

Fulton, Roseanne. *A Case Study of Culturally Responsive Teaching in Middle School Mathematics*. Kent Seidel, Chair, June 18, 2009, Outside Chair.

Grealy, Deborah S. *Tribes and Territories in Library and Information Studies Education*. Bruce Uhrmacher, Chair, June 10, 2008, Committee Member.

McCord, J. Michael. *Developing a Standard of Care for Educational Malpractice*. Chair, April 15, 2011.

Priebe, Sarah J. *Distinguishing Effects of Domain and General Knowledge on Passage Fluency and Comprehension*. Jan Keenan, Chair. July 21, 2011, Outside Chair.

Snyder-Mondragon, Sandra M. *Institutional Factors that Impact the Retention of Graduate Students of Color in Schools of Library and Information Science: A Metaregression of Accredited Library School Statistics on Student Retention and Graduation Rates*. Kathy Green, Chair, July 24, 2009, Committee Member.

Taylor, Karen Pickles. *Effective Teaching*. Elinor Katz, Chair, July 15, 2009, Outside Chair.

Thompson, Jennifer. *Distinguishing a Western Women's College: A History of the Curriculum and Student Experience at Colorado Women's College*. Edith W. King, Chair, July 16, 2010, Committee Member.

Walker, Emelda. *Influence of Organizational Factors on Job Satisfaction of Disability Service Providers at Postsecondary Institutions*. Chair, April 29, 2010.

Dissertation Proposals at the University of Denver

Bowers, Stacey L. *Library Anxiety of Law School Students: A Study Utilizing the Multidimensional Library Anxiety Scale*. Chair, November 5, 2009.

McCord, J. Michael. *Developing a Standard of Care for Educational Malpractice*. Edith W. King, Chair. April 23, 2010.

Thompson, Jennifer. *History of Colorado Women's College*. Edith W. King, Chair, October 30, 2008. Committee Member.

Walker, Emelda. *Influence of Organizational Factors on Job Satisfaction of Disability Service Providers at Postsecondary Institutions*. Chair, July 21, 2009.

Dissertations at Other Institutions

Rodríguez-Mori, Howard. *The Information Behavior of Puerto Rican Immigrants to Central Florida, 2003-2009: Grounded Analysis of Six Case Studies Use of Social Networks during the Migration Process*. Kathleen Burnett, Chair, April 10, 2009, Florida State University, Committee Member.

Schwartz, Brian *More than a Look-up Skill: Medical Information Literacy Education in Osteopathic Medical Schools*. D. Mirah Dow, Chair, July 18, 2017. Emporia State University, Committee Member.

Snow, Karen. *A Study of the Perception of Cataloging Quality among Catalogers*. Shawne D. Miksa, Chair, August 1, 2011. University of North Texas, Committee Member.

Dissertation Proposals at Other Institutions

Schwartz, Brian *More than a Look-up Skill: Medical Information Literacy Education in Osteopathic Medical Schools*. D. Mirah Dow, Chair, December 4, 2015. Emporia State University, Committee Member.

Snow, Karen. *A Study of the Perception of Cataloging Quality among Catalogers*. Shawne D. Miksa, Chair, May 11, 2010. University of North Texas, Committee Member.

Master's Thesis at the University of Denver

Hemingson, Jeff. *Recital Paper*. Lamont School of Music, February 2010, Outside Chair.

Capstones at the University of Denver

Anthony, Alisa. *Correlation of Library and Information Science Program outcomes and Vacant Position Qualifications Listed on the Colorado State Library Jobline by Employers During the Period September 1, 2000 through August 31, 2002*. Chair, Winter Quarter, 2003.

Borden, Donna M. *Improving Emergency Communications Systems: Is a Radio Communications Network the Answer?* Fall Quarter, 2014.

Bowden, Heather L.M. *Exploring Biological Models for Long-term Data Preservation*. Chair, Spring Quarter, 2008.

Casenada, Cassandra Y. *Challenges to the Recruitment, Education, and Retention of Librarians of Color*. Chair, Spring Quarter, 2008.

Chang, Jennifer C. *Legal Research Practice and Preference: A Law Firm Perspective*. Chair, Spring Quarter 2011.

Ellis, Megan S. Fitzgerald. *Design of a Public Library Adult Volunteer Recruitment Program and Training Curriculum*. Chair, Winter Quarter, 2003.

Kircher, Kathy. *Development of a Library Pathfinder for Exobiology and Posting it on the Internet*. Chair, Winter Quarter, 2003.

Melhado, Loretta. *Design of St. John's Episcopal Church Library*. Chair, Spring Quarter, 2008.

Radcliff, Kathy. *Original Cataloging of Archival materials in the HERS Collection in Penrose Library*. Chair, Winter Quarter, 2003.

Sass, Carol Ann. *ACT Periodical Index: Access to Catholic Thinking Periodical Index: Web Index to Select Catholic Periodicals*. Spring Quarter 2000.

Stone, Sergio D. *Conducting Community Analysis for the Bemis Public Library (Littleton, Colorado) Using 2002 U.S. Census Data and the Online Outcome-Based Evaluation Toolkit*. Chair, Winter Quarter, 2003.

Tureson, Tamara. *Design and Use of an Information Audit Tool for Use in a Law Library*. Chair, Winter Quarter, 2003.

Tweed, Beth. *Evaluation of Email Reference Service in a Consumer Health Library Environment*. Chair, Winter Quarter, 2003.

GRANTS AND CONTRACTS

Student Learning in Agriculture STEM through Teacher Professional Development. Research team: Stanton Gartin (PI) and Cyndi Hofmeister, Northeast Junior College; Jeff Cash, Cheryl Sánchez, Anne-Marie Crampton, Lamar Community College; Suzanna Spears, Morgan Community College; Jack Wiley, Kerry Gabrielson, Trinidad State Junior College; Michael J. Miller, Colorado State University; Michael Womochil (Co-PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Agriculture, Agriculture and Food Research Initiative, Food, Agriculture, Natural Resources and Human Sciences Education and Literacy Initiative, \$404,460 (2017-2020)

Leading and Achieving: the Colorado Agriculture Regional Consortium. Research team: Jack Wiley (PI), Kerry Gabrielson, Trinidad State Junior College; Jeff Cash (PI), Cheryl Sánchez, Anne-Marie Crampton, Lamar Community College; Suzanna Spears, Morgan Community College; Cyndi Hofmeister, Northeast Junior College; Michael Womochil (Co-PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Agriculture, Hispanic Serving Institutions Education Grants Program, \$504,414 (2017-2020)

Cyber Prep Program Planning Grant. Research team: Debbie Sagen (PI), Brenda Lauer, Pikes Peak Community College; Gretchen Martin, Koiosa Insights; and, Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Commerce, Regional Alliances and Multi-stakeholder Partnerships to Stimulate (RAMPS) Cybersecurity Education and Workforce Development, \$199,681 (2016-2018)

Career and Technical Education in Colorado: Pathways to Education and Employment. Research team: Heather McKay (PI), Rutgers University; Sarah Heath, Casey Sacks, Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Education, Institute of Education Sciences, \$1,400,000 (2017-2021)

Pre-Alliance Planning Grant Colorado Community College Alliance. Research team: Victor Vialpondo (PI) and Janel Highfill, Community College of Aurora; Heidi Loshbaugh (Co-PI), Community College of Denver; Rick Reeves, Bill McGreevy, Liz Cox, and Kristin Aslin, Red Rocks Community College; Cathy Pellish, Front Range Community College; Samuel DeVries, Arapahoe Community College; Sylvia D. Hall-Ellis, Colorado Community College System. National Science Foundation, Louis Stokes Alliance for Minority Participation (LSAMP), \$86,817 (2016-2017)

Towards Scalable Differentiated Instruction Using Technology-enabled, Competency-based, Dynamic Scaffolding. Research team: Karen Wilcox (PI) and Vijay Kumar, Center for Computational Engineering, Massachusetts Institute of Technology; Flora McMartin, Broad-based Knowledge; Quinsigamond Community College; and, Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Education, First in the World Developmental Grant, \$2,891,882 (2015-2019)

Colorado Strategic Partnerships Emergency Grant. Research team: Elise Lowe-Vaughn (PI), Amy Hodson, Celia Hardin, Barbara McBride, James Newby, Christopher Dewhurst, Nina Holland, Kate Anderson, MaryAnn Roe, Chrystalynn Chrystalynn, Elaine Edon, Mona Barnes, Tom Morgan, Rob Hanni, and Marie Valenzuela, Colorado Department of Labor and Employment; Steve Anton, Joelle Brouner, and, Katie Griego, Colorado Department of Human Services; Rebecca Holmes, Judith Martinez, and Jennifer Jirous, Colorado Department of Education; Emily Templin Lesh, Colorado Workforce Development Council; Cory Everett, Colorado Department of Regulatory Agencies; and, Casey Sacks and Sylvia D. Hall-Ellis, Colorado Community College System. U.S. Department of Labor, Strategic Partnerships Emergency Grant, \$5,000,000 (2015-2017)

CAEL Jump Start Program: Competency-Based Education. Research team: Jerry Migler (PI), Casey Sacks, Debra Cohn, Thomas Hartman, and Sylvia D. Hall-Ellis, Colorado Community College System; Matt Jamison, Front Range Community College; Mike Coste, Red Rocks Community College; Amanda Corum, Pueblo Community College; Janet Colvin, Pikes Peak Community College; and, MaryAnn Matheny, Community College of Denver. Council for Adult and Experiential Learning, \$15,000 (2015)

Summit on the Redesign of Developmental Education. Research team: Jerry Migler (PI), Casey Sacks, and Sylvia D. Hall-Ellis, Colorado Community College System; Chip Nava, Pueblo Community College; Kim Moultny, Arapahoe Community College; Debbie Ulibarri, Trinidad State Junior College; and, Kris Bernard, Front Range Community College. American Association of Community Colleges, \$15,000 (2015-2016)

Equity in Excellence at Colorado Community Colleges. Research team: Keith Howard (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Estela Mata Bensimon, Center for Urban Education, University of Southern California; and Kerry Gabrielson, Trinidad State Junior College. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, \$150,000 (2015-2016)

MBA High School of Business in Colorado. Research team: Laurie Urich (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Rudolph Sumpter and Beatrice Gerrish, Boulder Valley Schools; Keith Curry Lance, RSL Research Group. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, \$501,295 (2015-2016)

Fullbridge Program in Colorado. Research team: Keith Howard (PI) and Sylvia D. Hall-Ellis, Colorado Community College System; Suzanna Spears, Fort Morgan Community College; and, Cheryl Sánchez and Anne-Marie Compton, Lamar Community College. Colorado Department of Higher Education, Colorado Opportunity Scholarship Program, \$300,000 (2015-2017)

Colorado Community College System Alternative Credit Program. Research team: Jerry Migler (PI), Keith Howard, and Sylvia D. Hall-Ellis, Colorado Community College System. American Council on Education, \$13,000 (2015)

Internationalization in Higher Education. Researcher: Samuel D. Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$8,000 (2014-2015)

International Perspectives on Bilingual Education. Researcher: Sharolyn Pollard-Durodola. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$3,700 (2014-2015)

Cultivating Culturally Relevant and Responsive Curriculum and Pedagogy in College. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, iRise Grant, \$5,000 (2014-2015)

Project EMERGE (Educational Model for Evaluation and Replicability in Gifted Environments). Research team: Norma Hafenstein (PI) and Bruce Uhrmacher. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Lynde and Harry Bradley Foundation, \$235,000 (2014-2015)

Collecting Asian American Refugee Stories. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. American Educational Research Association, Research Grant, \$5,000 (2014-2015)

Developing Expertise in Teaching K-5 Mathematics. Research team: Julie Sarama (PI) and Douglas H. Clements (Co-PI), in partnership with the School of Education at the University of Michigan. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, \$130,344 (2013-2015)

Investigation of the Long-Term Outcomes for Special Education Students. Researcher: Antonio Olmos-Gallos. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Jefferson County School District, Office of Assessment, \$40,000 (2014)

Refugee Community Collaboration. Researcher: Vicki Tomlin (PI) in partnership with the African Community Center and Jewish Family Service. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, \$14,854 (2014-2015)

Access to Mathematics for All. Research team: Richard S. Kitchen (PI), Nicole M. Russell (Co-PI), and Terrence Blackman (Co-PI), Curriculum Studies and Teaching Program, Morgridge College of Education; Álvaro Árias (Co-PI, Department of Mathematics); and, James Gray (Co-PI), Department of Mathematics, Community College of Aurora. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, The Robert Noyce Scholarship Program, Capacity Building Project, \$349,926 (2014-2016)

Cognitive Test Battery for Intellectual Disabilities. Research team: Karen Riley (PI), Lyndsay Agans, Jessica Lerner, and Karin Dittrock-Nathan in partnership with David Hessel (PI), The MIND Institute at the University of California – Davis, and Elizabeth Berry-Kravis, Rush University Medical Center. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Institutes of Health, Outcome Measures for Use in Treatment Trials for Individuals with Intellectual and Developmental Disabilities (R01), \$2,499,996 (\$588,672 at DU) (2014- 2019)

Broadening Participation in Engineering among Women and Latino/as: A Longitudinal, Multi-Site Study. Researcher: Patton Garriott (PI) in partnership with the University of North Dakota and the University of Missouri. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, HER Core Research, \$677,390 (\$69,992 at DU) (2014-2019)

Designing a Teacher Evaluation System to Improve Teacher Effectiveness for Culturally and Linguistically Diverse Learners. Research team: María del Carmen Salazar (PI), Jessica Lerner, and Kathy Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, \$29,988 (2014-2016)

Developing a College-Going Culture in Latina/O Families: Exploring the Influence of Funds of Knowledge on Family Outreach Programs. Researcher: Judy Marquez Kiyama. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, \$18,720 (2014-2016)

Assessment of Quality of Life in Neural Implantation Surgery for the Treatment of Parkinson's Disease. Researcher: Cynthia McRae. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$3,967 (2014-2015)

Pura Vida: Cloud Forest, Curriculum and Cross-Cultural Study. Research team: Norma Hafenstein (PI) and Bruce Uhrmacher (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$8,000 (2014-2015)

Online Course Development for Curriculum and Instruction. Researcher: Ruth Chao. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: María del Carmen Salazar. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: Jessica Lerner. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$3,000 (2014)

Online Course Development for Curriculum and Instruction. Researcher: Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$3,000 (2014)

The Mathematics Education of African Americans, 1866 – 1954. Researcher: Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Academy of Education, Spencer Foundation Postdoctoral Fellowship, \$55,000 (2014-2016)

- Early Childhood Care and Education Study*. Research team: Carrie Germeroth (PI), Melissa Mincic, and Douglas H. Clements. Technical reviewer for MCE: Sylvia D. Hall-Ellis. State of North Dakota, Department of Public Instruction, \$73,500 (2013-2014)
- Graduate Level Specialty in Addiction Counselor Training with Emphasis on Integration of Native American Specific Content*. Research team: Ruth Chao (PI) and Michael J. Faragher (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. The Galena Foundation, \$289,732 (2013-2016)
- The Collecting Asian American and Pacific Islander Refugee Stories (CARS) Project*. Researcher: Samuel Museus. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, \$15,000 (2014)
- Parents in Transition: A Multiple Case Study of Parent and Family Orientation Programs*. Researcher: Judy Marqu  z Kiyama. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, \$1,500 (2014-2015)
- The Sistah Network: Black Women Graduate Students Supporting and Retaining Each Other*. Researcher: Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, \$2,708 (2014-2015)
- Evaluation of the Northeast Denver Babies Ready for College Program*. Research team: Carrie Germeroth (PI), Melissa Mincic, and Douglas H. Clements. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High Montessori, \$9,922 (2013-2014)
- Developing Teaching Expertise in K-5 Mathematics*. Research team: Julie Sarama (PI) and Douglas Clements (University of Denver), in partnership with Timothy Boerst (PI), Meghan Shaughnessy, Deborah Ball, Hyman Bass (School of Education at the University of Michigan). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, \$449,827 (\$130,344 at the University of Denver (2013-2015)
- Early Learning Care and Education Study Program Grant for the State of North Dakota*. Research team: Carrie Germeroth (PI), Melissa Mincic, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. State of North Dakota Department of Public Instruction, \$73,500 (2013-2014)
- Local Professional Learning Community for School Leaders*. Research team: Susan Korach (PI), Kristina Hesbol, and Rebecca McClure. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Education Development Center, \$10,950 (2013)
- Healthy Eaters, Lifelong Movers 2: Implementing Evidence-Based School Environment, Policy, and Curricular Changes to Increase Opportunities for Healthy Eating and Physical Activity in Low Income, Rural Colorado*. Research team: Elaine Berlansky, University of Colorado at Denver (PI), Nicholas Cutforth, University of Denver (Co-PI), and Allison Reeds. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, \$3,103,108 (2013-2017)
- Hughes Rare Books Library Room Renovation in the Sturm College of Law*. Project team: Patti H. Marks, Sylvia D. Hall-Ellis, and Leigh Elliott. Mabel T. Hughes Charitable Trust, \$34,000 (2013-2014)
- The Promise Center Partnership with the Marsico Institute for Early Learning and Literacy and the City and County of Denver*. Research team: Karen Riley (PI), Douglas H. Clements (Co-PI), and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. The Piton Foundation, \$223,468 (2013-2014)
- Center of Excellence for Problem Gambling*. Research team: Ruth Chao (PI) and J. Mike Faragher. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, \$68,021 (2012-2013)

United Way Implementation and Validation Review. Research team: Douglas H. Clements (PI), Amanda Moreno, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High United Way, \$19,737 (2013)

Math/Science Partnership in Rural Districts. Research team: Kristen Bunn (PI, Eagle County Schools), Paul Michalec (Co-PI), and Alegra Reiber. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Education, Colorado's Mathematics and Science Partnership Program, \$750,000 (2013-2014)

Mathematics and Science Education of African Americans. Research team: Nicole Russell (PI), Sylvia D. Hall-Ellis, Steve Fisher (Penrose Library). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, \$29,994 (2013-2015)

Online Course Development for Curriculum and Instruction. Researcher: Nicole Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$3,000 (2013)

Discourse and Opportunity: Undocumented Students and Higher Education Policy. Researcher: Ryan Gildersleeve. Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Academy of Education, Spencer Foundation Postdoctoral Fellowship, \$55,000 (2012-2014)

An Anthropological Study of the Latino Graduation Ceremony. Researcher: Ryan Gildersleeve. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Spencer Foundation, \$39,900 (2012-2013)

Fragile-X and Pharmaceutical Company: Clinical Trial of AFQ056. University of California – Davis Children's Hospital MIND Institute (Sacramento), Children's Hospital Denver, and Rush Children's Hospital at Rush University Medical Center (Chicago). Karen Riley, PI. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Novartis Pharmaceuticals Corporation, \$394,206 (2012-2014)

Project Engage, Phase 2, a DAPRA Grant in partnership with Total Immersion Systems, Inc., and Texas A&M University. Research team: Karen Riley (PI) and Lyndsay Agans (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Defense, \$60,000 (2011-2013)

International School Psychology Practicum Exchange. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, \$14,951 (2012-2013)

Online Course Development for Curriculum and Instruction. Research team: Bruce Uhrmacher (PI) and Norma Hafenstein (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Teaching and Learning, \$18,193 (2012-2014)

Writers in the Schools. Research team: Karen Riley (PI) and Amanda Moreno (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Humanities, \$4,965 (2012-2013)

Learning Ecosystem Validation Grant. Research team: Karen Riley (PI), Lyndsay Agans, Kent Seidel, and Shimelis Assefa. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Bill & Melinda Gates Foundation, \$315,000 (2012-2013)

Project Words of Oral Reading and Language Development (WORLD). Research team: Jorge E. Gonzalez (PI), Texas A&M University; Laura Saenz (Co-PI), University of Texas – Pan American; and, Sharolyn Pollard-Durodola (Co-PI), University of Denver. Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, \$53,354 (2012-2015); award \$640,718, transfer from Texas A&M University

Increasing the Efficacy of an Early Mathematics Curriculum with Scaffolding Designed to Promote Self-Regulation.

Research team: Douglas H. Clements (PI) and Julie Sarama (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, \$1,445,315 (2008-2014); award \$4,541,975, transfer from University at Buffalo, The State University of New York

Using Rule Space and Poset-based Adaptive Testing Methodologies to Identify Ability Patterns in Early

Mathematics and Create a Comprehensive Mathematics Ability Test. Research team: Douglas H. Clements (PI) and Julie Sarama (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, \$323,791 (2010-2014); award \$1,194,944, transfer from University at Buffalo, The State University of New York

Comprehensive Postdoctoral Training in Scientific Education Research. Researcher: Julie Sarama (PI). Technical

reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Education, Institute of Education Sciences, \$133,458 (2010-2014); award \$613,353, transfer from University at Buffalo, The State University of New York

Longitudinal Study of a Successful Scaling Up Project: Extending TRIAD. Research team: Douglas H. Clements

(PI), Julie Sarama (Co-PI), and Abt Associates (Carolyn Layzer, Fatih Unlu, Laurie Bozzi, Lily Fesler, Alina Martinez, Cristofer Price, James van Orden). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Institute of Education Sciences, \$384,940 (2011-2015; award \$1,250,286, transfer from University at Buffalo, The State University of New York

Early Childhood Education in the Context of Mathematics, Science, and Literacy. Research team: Julie Sarama (PI),

Douglas H. Clements (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. National Science Foundation, \$990,020 (2010-2014; award \$2,285,228, transfer from University at Buffalo, The State University of New York

Early Childhood Clearinghouse Information Center Redesign. Research team: Karen Riley (PI) and Amanda

Moreno (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Office of the Lt. Governor of Colorado, \$12,000 (2012-2013)

Morgridge Rural Educational Leadership Initiative. Research team: Lyndsay Agans (PI), Linda Brookhart (Co-PI),

Susan Korach, and Rebecca McClure. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Morgridge Family Foundation, \$100,000 (2012-2014)

Center of Excellence for Problem Gambling. Research team: Patrick Sherry (PI) and J. Mike Faragher. Technical

reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, \$55,000 (2012-2013)

Intermodal Transportation Institute Research Initiatives. Researcher: Patrick Sherry. Technical reviewer for MCE:

Sylvia D. Hall-Ellis. University Transportation Centers Program, Research and Innovative Technology Administration, U.S. Department of Transportation. \$600,000 (2012-2014)

Mile High United Way Social Innovation Fund Early Literacy Initiative. Gloria L. Miller, PI, Amanda Moreano,

Kim Hartnett-Edwards, and Sheridan Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Mile High United Way, \$89,992 (2012-2013)

International School Psychology Practicum Exchange. Researcher: Gloria L. Miller. Technical reviewer for MCE:

Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, \$1,000 (2012-2013)

Refugee Student Art Outreach. Researcher: Karin Dittrock-Nathan. Technical reviewer for MCE: Sylvia D. Hall-

Ellis. University of Denver, Faculty Research Fund, \$3,000 (2012-2013)

- Resistance, Resilience, and Reciprocity: Centering the Voices of Black Doctoral Women with Faculty Aspirations.* Researcher: Nicole M. Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, \$2,965 (2012-2013)
- Assessing Learning through Student Notebooks.* Research team: Keith Miller, Nancy Sasaki, and Kathy Green. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Professional Research Opportunities for Faculty, \$30,000 (2012-2014)
- International School Psychology Practicum Exchange.* Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$2,000 (2012-2013)
- ELO in Colorado.* Research team: Cynthia Hazel and Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Legacy Foundation, \$150,000 (2012-2013)
- Creating Online LIS Courses.* Research team: Mary C. Stansbury (PI), Shimelis Assefa, Denise Anthony, Xiao Hu, and Krystyna Matusiak. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, \$15,000 (2011-2013)
- Maritime Piracy Seminar.* Researcher: Ved Nanda, The Nanda Center, Sturm College of Law. Technical reviewer for Sturm College of Law: Sylvia D. Hall-Ellis. Arsenault Family Foundation, \$15,000 (2012-2013).
- Early Childhood Librarianship: An Interdisciplinary, Experiential Learning MLIS.* Researcher: Mary C. Stansbury (PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Laura Bush's 21st Century Librarians Program, Institute for Museums and Library Services, \$249,066 (2012-2014)
- Learning Ecosystem Planning Grant.* Research team: Karen Riley (PI), Lyndsay Agans, Kent Seidel, and Shimelis Assefa. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Bill & Melinda Gates Foundation, \$281,217 (2011-2012)
- Advanced Service Learning Practitioner Faculty Grant,* Sylvia D. Hall-Ellis, University of Denver, Center for Community Engagement and Service Learning, \$400 (2011)
- Evaluating and Enhancing the EspeciallyMe Program.* Research team: Lori D. Patton and Nicole Russell. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, Public Good Fellowship Grant, \$24,780 (2012)
- Choosing Excellence: Let Every Child Bloom.* Research team: Shimelis Assefa (PI) and Mary C. Stansbury (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Community Engagement and Service Learning, Public Good Grant, \$7,657 (2012)
- K-8 STEM Content Specific Professional Development to Improve Elementary Student Achievement.* Research team: Kent Seidel (PI), Nicole Russell (Co-PI), Kimberly Hartnett-Edwards, Paul Michalec, Jeff Farmer, Keith Miller, Alegra Reiber, and Nancy Sasaki. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Education, Improving Teacher Quality Grant, (Title II ESEA), \$307,299 (2011-2012)
- Building a Better Principal Pipeline to Boost Student Achievement.* Researcher: Susan Korach. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Denver Public Schools; a subcontract from the Wallace Foundation Grant, \$170,000 (2011-2017)
- Center of Excellence for Problem Gambling.* Research team: J. Mike Faragher (Co-PI) and Bobbie Vollmer (PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Department of Behavioral Health, \$79,999 (2011-2012)

An Exploration of Novice Teachers' Core Competencies: Impacts on Student Achievement, and Effectiveness of Preparation. Research team: Kent Seidel (PI), Kathy Green (Co-PI), Kimberly Hartnett-Edwards, and Duan Zhang. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Institute of Education Sciences, Effective Teachers and Effective Teaching, \$990,987 (2012-2015)

Project Engage, a DAPRA Grant in partnership with Total Immersion Systems, Inc., and Texas A&M University. Research team: Karen Riley (PI) and Lyndsay Agans (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. U.S. Department of Defense, \$49,964 (2011-2014)

User-centered Evaluation of Music Search Engines. Researcher: Xiao Hu. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Faculty Research Fund, \$2,931 (2011-2012)

Educational Practicum in Vietnam and China to Promote the Inclusion of Young Children with Disabilities. Researcher: Gloria L. Miller. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Office of Internationalization, \$5,000 (2011-2012)

Evaluation of Colorado's Enhancing Quality in Infant-Toddler (EQIT) Initiative. Research team: Virginia R. Maloney and Amanda Moreno. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Buell Foundation, \$395,884 (2011-2013)

Creating Engaging Environments to Teach Pre-Algebra Mathematics to Elementary Students. Research team: Álvaro Arias, Mario López, María del Carmen Salazar, and Lyndsay Agans. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver Interdisciplinary Grant, \$60,000 (2011-2012)

Morgridge Education Technology Accessible (META) Resource Project. Research team: Lyndsay Agans (PI) and Shimelis Assefa (Co-PI). Technical reviewer for MCE: Sylvia D. Hall-Ellis. Morgridge Family Foundation, \$36,000 (2011)

MCE Connect: A 21st Century Framework for Faculty Development. Research team: Bruce Uhrmacher (PI), Shimelis Assefa (Co-PI), Lyndsay Agans (Co-PI), Kimberly Hartnett-Edwards, Norma Hafenstein, Xiao Hu, Paul Michalec (Co-PI), María del Carmen Salazar (Co-PI), and Sandra Snyder-Mondragon. Technical reviewer for MCE: Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, \$22,355 (2011-2012)

Parent Education and Parent Leadership and Advocacy. Research team: Virginia Maloney (PI) and Amanda Moreno, Marsico Institute for Early Learning and Literacy. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, \$27,358 (2010-2011)

Intentional School Culture. Researcher: Cynthia Hazel. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Denver Public Schools, \$38,040 (2010-2011)

Healthy Eaters, Lifelong Movers: Implementing Evidence-Based School Environment, Policy, and Curricular Changes to Increase Opportunities for Healthy Eating and Physical Activity in Low Income, Rural Colorado. Research team: Elaine Berlansky, University of Colorado at Denver (PI), Nicholas Cutforth, University of Denver (Co-PI), and Allison Reeds. Technical reviewer for MCE: Sylvia D. Hall-Ellis. Colorado Health Foundation, \$1,683,277 (2011-2014)

Second Life Learning Community. Research team: Don McCubbrey (PI), Sylvia D. Hall-Ellis (Co-PI), Walter LaMendola, and Paul Novak. University of Denver, Center for Teaching and Learning, \$13,000 (2010-2011)

Reintroducing the Value of Law Librarians to Academic and Public Librarians in Colorado through the Identification and Use of Emerging Technologies. Research team: Sylvia D. Hall-Ellis (Co-PI), Stacey L. Bowers (PI), and Christopher Hudson, in partnership with Denver Public Library, Arapahoe Library District, and the Colorado State Supreme Court Library. University of Denver, Center for Community Engagement and Service Learning, \$5,773 (2010-11)

Reintroducing the Value of Law Librarians to Public Librarians through the Identification and Use of Emerging Technologies and Resources. Research team: Stacey Bowers (PI) and Sylvia D. Hall-Ellis (Co-PI). American Association of Libraries, Wolters Kluwer Law & Business Grant Program, \$2,725 (2010-2011)

Faculty Service Learning Pod. Research team: María del Carmen Salazar and Nicholas Cutforth (Curriculum and Instruction Program), Frank Tuitt (Higher Education Program), Cynthia Hazel and Gloria Miller (Child, Family, and School Psychology Program), and Sylvia D. Hall-Ellis (Library and Information Science Program). University of Denver, Center for Community Engagement and Service Learning, \$8,000 (2010-2011)

Lincoln Collaborative. Research team: Antonio Esquibel (Principal, Lincoln High School), María del Carmen Salazar (Curriculum and Instruction Program), and Sylvia D. Hall-Ellis. School Improvement Grant, Denver Public Schools, \$375,000 (2010-2012)

Future LEADers of America: Leaders III. Research team: Denver Public Library (Kristen Svendsen, PI), the University of Denver (Sylvia D. Hall-Ellis), the Colorado Chapter of REFORMA (Orlando Archibeque), and the Colorado Association of Libraries (Martin Garnar). Laura Bush's Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, \$988,366 (2009-2012)

Teaching for Success in the Library Environment: LIS 4030 in Library 2.0. Research team: Deborah S. Grealy (PI) and Sylvia D. Hall-Ellis (Co-PI). University of Denver, Center for Teaching and Learning, \$ 9,350 (2009-10)

Writing Group Faculty Grant, Sylvia D. Hall-Ellis, University of Denver, Center for Community Engagement and Service Learning, \$750 (2008-2009)

Collaborative Learning Faculty Grant, Sylvia D. Hall-Ellis, University of Denver, Center for Teaching and Learning, \$1,500 (2008)

Connecting Information Literacy to Learning. Research team: Lori Micho, Merrie Valliant, Amanda Samland, and Sylvia D. Hall-Ellis. Colorado State Library, LSTA Discretionary Grant Program, \$19,548 (2008-2009)

Law Librarianship Fellows Program. Research team: Sylvia D. Hall-Ellis (PI), Stacey Bowers (Co-PI), and Christopher Hudson, Westminster Law Library. Laura Bush's 21st Century Librarians Program, Institute for Museums and Library Services, \$999,370 (2008-2012)

Grant Writing in a Cooperative Learning Environment. Sylvia D. Hall-Ellis. University of Denver, Center for Teaching and Learning, \$2,000 (2008-2009)

Project Homeless Connect 6 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, \$9,785 (2008)

Project Ecuador: International Learning Service Libraries – A Faculty Development Experience in Ecuador. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, \$600 (2007)

Project Ecuador: International Learning Service Libraries – A Faculty Development Experience in Ecuador. Sylvia D. Hall-Ellis, International Service Learning Office, University of Denver, \$400 (2007)

Project Homeless Connect 5 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, \$1,000 (2007)

Project Homeless Connect 4 Event Evaluation. Research team: Sylvia D. Hall-Ellis and Duan Zhang. University of Denver Center for Community Engagement and Service Learning, \$4,595 (2007)

Future LEADers of America: Leaders II. Research team: Denver Public Library (Kristen Svendsen, PI), the University of Denver (Sylvia D. Hall-Ellis), and the Colorado Chapter of REFORMA (Orlando Archibeque). Laura Bush's Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, \$988,518 (2007-2010)

Strategic Planning Assistance for the Denver Medical Library. Sylvia D. Hall-Ellis. Denver Medical Library, Inc., \$30,000 (2006-2007)

Destiny Software for JMAC Student Lab. Sylvia D. Hall-Ellis, gift from the Sagebrush Corporation, Minneapolis, Minnesota, \$10,000 (2006)

Libraries: Tools for Education and Development Worldwide: A Faculty Development Experience in France. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, \$800 (2005)

Denver Public Library: Opportunities for Change. Sylvia D. Hall-Ellis, Colorado Community Based Research Network, \$2,000 (2005)

Future LEADers of America. Research team: Denver Public Library (Letty Icolari and Steve Taylor, PIs), Emporia State University (Jim Agee), and the University of Denver (Sylvia D. Hall-Ellis). Recruiting Librarians for the 21st Century Program, Institute for Museums and Library Services, \$670,315 (2005-2008)

American Association of University Professors Summer Institute Professional Development Grant. Sylvia D. Hall-Ellis, American Association of University Professors, \$300 (2005)

Beta Phi Mu Alumni Tea. Sylvia D. Hall-Ellis, gift from the Office of Alumni and Parent and Relations, University of Denver, \$2,000 (2005)

Spectrum Software for LIS Student Lab. Sylvia D. Hall-Ellis, gift from the Sagebrush Corporation, Minneapolis, Minnesota, \$5,000 (2005)

Developing Research Capacity in Community Organizations and Residents through Training and Technical Assistance. Nicholas J. Cutforth (PI) and Sylvia D. Hall-Ellis. Piton Foundation, \$25,000 (2005-2006)

Libraries: Tools for Education and Development Worldwide: A Faculty Development Experience in Argentina. Sylvia D. Hall-Ellis, Office of Internationalization, University of Denver, \$500 (2004)

Developing Research Capacity in Community Organizations and Residents through Training and Technical Assistance. Research team: Nicholas J. Cutforth (PI), Gary Lichtenstein and Sylvia D. Hall-Ellis, Piton Foundation, \$25,000 (2003-2004)

Increasing Spanish-Speaking and Hispanic Diversity among Library and Information Science Students at the University of Denver: Development of a Student Recruitment Model. Researcher: Sylvia D. Hall-Ellis (PI), Office of Multicultural Excellence, University of Denver, \$2,750 (2003-2004)

Collection Development Enrichment to Support the Cataloging & Classification Specialization and School Librarianship within the Library & Information Science Program at the University of Denver. Research team: Sylvia D. Hall-Ellis (PI) and Deborah S. Greal. Women's Library Association, University of Denver, \$4,000 (2003)

Collection Development Enrichment to Support the Library & Information Science Program at the University of Denver. Research team: Deborah S. Grealy (PI) and Sylvia D. Hall-Ellis. Women's Library Association, University of Denver, \$4,000 (2001)

Wireless LAN for Library Education. Research team: Deborah S. Grealy (PI) and Sylvia Hall-Ellis. University of Denver, Center for Teaching and Learning, \$24,000 (2001-2002)

Upward Bound – A Program for South Texas Youth. Research team: Monte Churchill, Executive Director of Community Relations; Gary R. Saucedo, Outreach Coordinator; Raymond Hernandez, (PI) Associate Dean for Student Success; and Sylvia D. Hall-Ellis, South Texas Community College (McAllen, Texas). U.S. Department of Education, Office of Postsecondary Education, \$2,672,003 (1999-2003)

Write Now! Improving Elementary Students' Writing Skills. Research team: Caryl G. Thomason, Assistant Superintendent (PI); Karen Tankersley, Principal; and, Hal Anderson, Director of Technology, Cheyenne Mountain School District 12 (Colorado Springs, Colorado); and Sylvia D. Hall-Ellis. Colorado Department of Education, Educational Telecommunications Unit, \$189,453 (1999-2001)

Operation Quick Start -- Distance Learning in Rural Colorado. Research team: Randal Weigum, Technology Coordinator (PI); Bonnie Barns, Director of Federal Programs and Staff Development; and, Adam "Joe" Raskop, Executive Director, Southeastern Board of Cooperative Educational Services (Lamar, Colorado); and Sylvia D. Hall-Ellis. Colorado Department of Education, Educational Telecommunications Unit, \$400,000 (1999-2001)

Advanced Technological Training for Information Professionals for the 21st Century. Research team: Mario Reyna, Division of Business Director (PI) and Sylvia D. Hall-Ellis, South Texas Community College (McAllen, Texas). Phi Delta Kappa and the National Science Foundation, \$250,000 (1999-2001)

Working Connections – Training Information Technologies Professionals for the 21st Century. Research team: Mario Reyna, Division of Business Director (PI) and Sylvia D. Hall-Ellis, South Texas Community College (McAllen, Texas). Microsoft Corporation and the American Association of Community Colleges, \$1,147,775 (1999-2001)

The ROAD (Research Oriented Amplification of Development to Literacy) Program. Research team: Deborah J. Leong (PI), Metropolitan State University; Elena Bodrova, Metropolitan State University; Dmitri Semenov, Robert J. Marzano, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Foundation, \$25,000 (1998-1999)

Press to Literacy. Research team: Deborah J. Leong (PI), Metropolitan State University; Elena Bodrova, Metropolitan State University; Dmitri Semenov, Robert J. Marzano, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). The Denver Post and the Robert S. McCormick Foundation, \$49,818 (1998-1999)

International Telementor Center. Research team: David Neils, David B. Frost (PI), and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Philanthropy, \$100,000 (1998-1999)

America Reads: Providing Tutor Training for the America Reads Challenge. Research team: Louis F. Cicchinelli (PI) and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Department of Education, Office of Educational Research and Improvement, \$306,000 (1998-1999)

Comprehensive School Reform. Research team: Louis F. Cicchinelli (PI), J. Timothy Waters, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Department of Education, Office of Educational Research and Improvement, \$285,000 (1998-1999)

Sustainable Energy Education (SEE) Program for Grades 4-8: Preparing Today's Youth for Lifelong Learning and Responsible Actions in Energy Conservation. Research team: Mary Gromko, Colorado Department of Education; Gene McCarthy, Rocky Flats Field Office, U.S. Department of Energy; Gina Kissell, National Renewable Energy Laboratory; and Barbara L. McCombs (PI), Janet L. Bishop, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). State of Colorado Governor's Office for Energy Conservation, \$499,936 (1997-1999)

Review of Kansas Curriculum Standards in Mathematics and Language Arts. Research team: Robert J. Marzano (PI), John S. Kendall, David B. Frost, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Submitted to the Kansas State Department of Education, \$25,903 (1998)

International Telementor Center. Research team: David Neils, John Kuglin, Chris Rapp, David B. Frost (PI), and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). Hewlett-Packard Company, \$54,752 (1998)

Genesis Mission: Education Public Outreach. Developed in partnership by the Jet Propulsion Laboratory, California Institute of Technology, Los Alamos National Laboratory, Lockheed Martin Astronautics, and the Mid-continent Regional Educational Laboratory (Aurora, Colorado). Research team: John T. Sutton (PI), Alice Krueger, Martha Henry, Greg Rawls, Shae Isaacs, Jeff Johnson, Deb Jordan, Arlene Mitchell, David B. Frost, Jana Caldwell, J. Timothy Waters, and Sylvia D. Hall-Ellis. National Aeronautics and Space Administration, \$139,700,000; subcontract award, \$4,750,000 (1997-2007)

North Dakota Mathematics Assessment Project. Developed in partnership by the North Dakota Department of Education and Mid-continent Regional Educational Laboratory (Mid-continent Regional Educational Laboratory). Research team: Ann Clapper, Clarence Bina, Greg Gallagher, North Dakota Department of Education; Don Burger (PI), Hillary Michaels, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Office of Education, \$1,618,214; subcontract award, \$389,076 (1997-2001)

Pacific Resources for Education and Learning Distance Education: Project Evaluation. Developed in partnership by the Pacific Educational Community, the Pacific Resources for Education and Learning (PREL), and Mid-continent Regional Educational Laboratory (McREL). Research team: John W. Kofel (PI), Executive Director, PREL; J. Timothy Waters, Executive Director; Joan Buttram, Robert Keller, and Sylvia D. Hall-Ellis, Mid-continent Regional Educational Laboratory (Aurora, Colorado). U.S. Office of Education, Star Schools Program, \$10,000,000; subcontract award, \$500,000 (1997-2002)

Identification of Bilingual Gifted and Talented Children: A Comprehensive School Grants for Bilingual Education. Developed in partnership by Hidalgo (Texas) ISD, Los Fresnos (Texas) CISD, Progreso (Texas) ISD, University of Texas – Pan American (Edinburg, Texas), and Education Service Center, Region One (Edinburg, Texas). Research team: Hilda Medrano, Dean, College of Education, University of Texas – Pan American; Linda Phemister (PI), Janie Navarro, and Sylvia D. Hall-Ellis, Education Service Center, Region One. U.S. Department of Education, Office of Bilingual Education and Minority Languages Affairs, \$1,670,633 (1997-2002)

Academics 2000: First Things First -- The Texas Goals 2000. Developed for Jim Hogg (Hebbronville, Texas) County ISD, Mirando City (Texas) ISD, and San Isidro (Texas) ISD. Research team: Hilda Medrano, Dean, College of Education, University of Texas - Pan American (Edinburg, Texas); Angie Lehmann, Amy Mares, Ellen Gonzalez (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg, Texas). Texas Education Agency, \$339,987 (1997-2000)

Southwestern Bell's Learning Communities Initiative. Developed for Tech Prep of the Rio Grande Valley, Inc. (Harlingen, Texas); the Center for Professional Teacher Development, University of Texas – Brownsville; Teach for America – Rio Grande Valley (McAllen, Texas); and Education Service Center, Region One (Edinburg, Texas). Research team: Patricia G. Bubb, Executive Director (PI), Tech Prep of the Rio Grande Valley; Martin Winchester, Executive Director, Teach for America – Rio Grande Valley; Aileen Johnson, Director, School of Education, University of Texas – Brownsville; and Sylvia D. Hall-Ellis. Southwestern Bell Foundation, \$100,000 (1997-1998)

Texas School to Work: Regional Implementation. Developed for Tech Prep of the Rio Grande Valley, Inc. (Harlingen), South Texas Community College (McAllen), Texas State Technical College (Harlingen), Texas Southmost College (Brownsville), Empowerment Zone of the Rio Grande Valley (Mercedes), Project VIDA (Weslaco), Youth Fair Chance (McAllen), and Education Service Center, Region One (Edinburg). Research team: Patricia G. Bubb (PI), Tech Prep of the Rio Grande Valley; Stephen Vassberg, Texas State Technical College; Ellen Trevino, Youth Fair Chance; Wanda Garza, Project VIDA; Leonardo Olivares, University of Texas – Pan American; Michael Bell, South Texas Community College; and Sylvia D. Hall-Ellis. Texas Workforce Commission, \$4,250,000 (1997-2002).

Comprehensive Bilingual Education Grant for Hidalgo ISD and Roma ISD. Developed for Hidalgo (Texas) ISD, Roma (Texas) ISD, College of Education, University of Texas – Pan American (Edinburg, Texas), and Education Service Center, Region One (Edinburg, Texas). Research team: Tomas Thomas (PI), Director, Office of Bilingual Education and Sylvia D. Hall-Ellis. U.S. Department of Education, Office of Bilingual Education and Minority Languages Affairs, \$1,531,361 (1997-2002)

Lopez High School, Porter High School, Rivera High School, Central Middle School, and Perkins Middle School, Brownsville (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$1,473,611 (1997-1998)

Donna High School, Todd Middle School, and Solis Middle School, Donna (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$704,052 (1997-1998)

Memorial Middle School and Nellie Schunior Middle School, La Joya Independent School District (Texas). Telecommunications Infrastructure Fund Board, \$293,641 (1997-1998)

Martin High School, Christen Middle School, Cigarroa Middle School, Lamar Middle School, Laredo (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$1,200,000 (1997-1998).

Lasara Middle School, Lasara (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$246,210 (1997-1998)

Los Fresnos High School and Resaca Middle School, Los Fresnos (Texas) Consolidated Independent School District. Telecommunications Infrastructure Fund Board, \$500,000 (1997-1998)

Lyford Junior High School, Lyford (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$354,997 (1997-1998)

Travis Middle School, McAllen (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$269,139 (1997-1998)

Mission High School, Mission (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$297,010 (1997-1998)

Progreso High School, Progreso (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$300,000 (1997-1998)

San Perlita High School, San Perlita (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$293,490 (1997-1998)

Myra Green Junior High School, Raymondville (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$225,000 (1997-1998)

Rio Grande City High School, Ringgold Middle School, Gruella Middle School, Rio Grande City (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$809,934 (1997-1998)

Rio Hondo Junior High School, Rio Hondo (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$297,024 (1997-1998)

Roma High School, Roma (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$333,178 (1997-1998)

San Benito High School, Miller Jordan Junior High School, San Benito (Texas) Consolidated Independent School District. Telecommunications Infrastructure Fund Board, \$547,000 (1997-1998)

Santa Maria High School and Santa Maria Middle School, Santa Maria (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$400,000 (1997-1998)

Salvador High School, United Independent School District (Laredo, Texas). Telecommunications Infrastructure Fund Board, \$250,879 (1997-1998)

Weslaco High School, Cabaza Middle School, Cuellar Middle School, Weslaco (Texas) Independent School District. Telecommunications Infrastructure Fund Board, \$874,242 (1997-1998)

Principals' Assessment and Training Center. Developed for Education Service Center, Region One (Edinburg, Texas). Research team: Roberto Zamora, Leonel Barrera, William H. Parry, and Sylvia D. Hall-Ellis. Texas Principals' Leadership Initiative, Texas Association of Secondary School Principals, Texas Association of Elementary School Principals, and the Sid Richardson Foundation. \$461,439 (1996-1998)

The Texas Library Connection -- Integrating and Sharing Resources. Developed for Hidalgo County Library System (McAllen), Cameron County Library System (Brownsville), South Texas Community College (McAllen), the University of Texas - Pan American (Edinburg), University of Texas – Brownsville, and Education Service Center, Region One (Edinburg). Research team: William R. McGee, Coordinator, Hidalgo County Library System; Joe Garcia, Director, Cameron County Library System; Michael D. Bell, Library Director, South Texas Community College; Eleanor Folger Foster, University Library, University of Texas - Pan American; Jaime Vela (PI), Director of Instructional Technology and Media Services, Ron Pontius, Instructional Technology, and Fabiola Fuentes, Media Services, Education Service Center, Region One; and Sylvia D. Hall-Ellis. Office of Library Media Services, Technology Services, Texas Education Agency. \$8,000 (1996-1997)

Developing Leadership Communities for Improving Algebra I for All Students. Developed for a partnership of the Region One Statewide Systemic Initiative Team. Research team: Noel Villarreal (PI), Eduardo Cancino, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Statewide Systemic Initiative for Reform in Mathematics, Science and Technology Education to The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin. \$25,000 (1996-1997)

Academics 2000: First Things First -- The Texas Goals 2000. Developed for Edinburg (Texas) CISD. Research team: Hilda Medrano, Dean, College of Education, University of Texas - Pan American (Edinburg); Helen Jones, Director (PI), Gifted and Talented Education, Edinburg CISD; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, \$750,000 (1996-2001)

Texas Teachers Empowered for Achievement in Mathematics (TEXTEAM) Institute for Algebra I. Developed for Hidalgo ISD, Jim Hogg (Hebbronville) County ISD, La Joya ISD, La Villa ISD, Lyford ISD, Mission CISD, Pharr-San Juan-Alamo ISD, Rio Hondo ISD, San Isidro ISD, San Perlita ISD, Santa Maria ISD, Santa Rosa, Sharyland ISD, Valley View ISD, Webb (Laredo) CISD, Weslaco ISD, and Zapata County (Zapata) ISD. Research team: Noel Villarreal (PI), Chuck McInteer, Ellen M. Gonzalez, Education Service Center, Region One (Edinburg); and Sylvia D. Hall-Ellis. Charles A. Dana Center for Mathematics and Science Education, University of Texas - Austin, \$15,975 (1996)

Community Learning Center for La Villa, Texas. Developed for Edcouch-Elsa Independent School District. Research team: Noe Gonzalez (PI), Assistant Superintendent, Edcouch-Elsa Independent School District, and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, \$325,000 (1996-1997)

Monte Alto (Texas) Community Learning Center. Developed for Monte Alto Independent School District. Research team: Homero A. Diaz (PI), Superintendent, Monte Alto Independent School District, and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, \$300,000 (1996-1997)

Community Learning Center for La Villa, Texas. Developed for La Villa Independent School District. Research team: Sam Gonzalez (PI), Assistant Superintendent, La Villa Independent School District; and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, \$325,000 (1996-1997)

Building Project for Taylor Elementary. Developed for Mercedes (Texas) Independent School District. Research team: Mrs. Denise Rivera, Librarian, and Eduardo Infante, Principal, Taylor Elementary School; Ismael S. Cantu (PI), Federal Programs Director, Mercedes Independent School District; and Sylvia D. Hall-Ellis. Delta Region Subzone, Rio Grande Valley (Texas) Rural Empowerment Zone, \$375,000 (1996-1997)

Border Education Network (BEN) - Distance Education through Cable Television. Developed for Edinburg (Texas) Consolidated Independent School District. Research team: Noe Torres (PI), Library Media Specialist, Magdalena Rosas, Library Media and Technology Coordinator, Edinburg Consolidated Independent School District; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Edinburg (Texas) Consolidated School District, \$250,000 (1996-1997)

Multiservice One-Stop Open Enrollment Charter School. Developed for the Information Referral Resource Assistance, Inc. (McAllen, Texas). Research team: Pablo Perez and Aguié Pena (PI), Executive Director, Information Referral Resource Assistance, Inc.; Roberto Zamora and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, \$3,066,000 (1996-2001)

Project OK: A Community Youth Opportunities Grant for Summer, 1996. Developed for McAllen (Texas) Independent School District, St. Joseph the Worker Catholic Church, and the Office of Adult Education, Education Service Center, Region One. Research team: Father Bart Flatt, St. Joseph the Worker Catholic Church; Noe Calvillo (PI), Office of Adult Education; Maria Louisa Garcia, McAllen Independent School District; and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Protective and Regulatory Agency through the Office of the Mayor, City of McAllen, \$350,000 (1996-2001).

Early Childhood: a Time of Discovery. Developed for a partnership of Lasara ISD, Rio Hondo ISD, San Perlita ISD, the School of Education, University of Texas - Brownsville, and Education Service Center, Region One (Edinburg). Research team: Hugo Rodriguez, Dean, School of Education, University of Texas - Pan American; Leonel Barrera and Jack Damron, Field Service Agents, Ellen M. Gonzalez (PI), Administrator for Student Instructional Services, Ruth Solis, Education Specialist in Special Education, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, \$722,090 (1996-2001)

Innovative Gifted and Talented Programs for Early Childhood and Elementary Education Students. Developed for a partnership of Edinburg (Texas) CISD, the School of Education, University of Texas - Pan American (Edinburg), and Education Service Center, Region One (Edinburg). Research team: Hilda Medrano, Dean, School of Education, University of Texas - Pan American; Helen de la Garza (PI), Director of Elementary Curriculum and Instruction, Edinburg CISD; and Sylvia D. Hall-Ellis. Texas Education Agency, \$750,000 (1996-2001)

Reading Recovery in Early Elementary Grades. Developed for a partnership of La Villa (Texas) ISD the School of Education, University of Texas - Pan American (Edinburg), and Education Service Center, Region One (Edinburg). Research team: Hilda Medrano, Dean, School of Education, University of Texas - Pan American; Marcario Salinas (PI), Supervisor of Elementary Curriculum and Instruction, La Villa ISD; and Sylvia D. Hall-Ellis, Education Service Center, Region One. Texas Education Agency, \$750,000 (1996-2001)

Connected Mathematics Project for Middle and Junior High Students. Developed for a partnership of Michigan State University, The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin and Region One Statewide Systemic Initiative Team. Research team: Jack Damron, Chuck McIneter, Noel Villarreal (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). National Science Foundation through Michigan State University to the Charles A. Dana Center at the University of Texas - Austin, \$539,610 (1996-1999)

Sharing Resources: Testing the Interlibrary Loan Potential of the Texas Library Connection -- Integrating Media Resources. Developed under the sponsorship of the Hidalgo County Library System (McAllen) and Education Service Center, Region One (Edinburg). Research team: William H. McGee, Hidalgo County System Coordinator; Fabiola Fuentes, Library Media; Ronald Pontius (PI), Instructional Technology, Education Service Center, Region One; and Sylvia D. Hall-Ellis. Library Media Services Program, Office of Technology Services, Texas Education Agency, \$25,000 (1996-1997)

State and Federal Adult Education JOBS Program. Developed for Education Service Center, Region One (Edinburg). Research team: Noe Calvillo (PI), Director, Adult Education Program, and Sylvia D. Hall-Ellis. Adult Education Program, Texas Education Agency, \$532,846 (1995-1996)

Creating Safe and Drug-Free Schools and Communities. Developed for a partnership of the Region One Consortium for Safe and Drug-Free Education Environments. Research team: Clara Contreras (PI), Health Specialist, and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Education Agency, \$150,000 (1995-1996)

Developing Leadership Communities for Improving Mathematics Performance for All Students on Title I Campuses. Developed for a partnership of the Region One Statewide Systemic Initiative Team. Research team: Jack Damron, Chuck McIneter, Noel Villarreal (PI), and Sylvia D. Hall-Ellis, Education Service Center, Region One (Edinburg). Texas Statewide Systemic Initiative for Reform in Mathematics, Science and Technology Education to The Charles A. Dana Center for Mathematics and Science Education, The University of Texas at Austin, \$50,669 (1995-1996)

The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in South Texas.

Sylvia D. Hall-Ellis (PI). Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville). Texas Association of School Librarians, Children's Services Round Table, and Young Adults Round Table (Austin, Texas), \$2,500 (1995)

School Library Media Specialists Fellowship Program. Sylvia D. Hall-Ellis (PI). Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville, Texas). U.S. Department of Education, HEA Title II-B, Library Education and Human Resource Development Program, \$44,000 (1995-1996)

Planning for Educational Technology. Research team: Ruth Ann Riggins (PI), Director of Library Media and Technology Services, Donna (Texas) Independent School District; Noe Torres, Education Service Center, Region One; Patricia G. Bubbs, Tech Prep of the Rio Grande Valley, Inc; Michael D. Bell, South Texas Community College; and Sylvia D. Hall-Ellis, Sam Houston State University. Developed under the sponsorship of Donna (Texas) Independent School District, Education Service Center, Region One (Edinburg), Tech Prep of the Rio Grande Valley, Inc. (Harlingen), South Texas Community College (McAllen), and the Department of Library Science, Sam Houston State University (Huntsville). Funded through Infusion of Educational Technology Planning Grant Program (H.B. 18: Models). Texas Education Agency, \$18,000 (1993-1994)

The Impact of Library Resource Centers on Academic Achievement in Selected Public Schools in South Texas.

Sylvia D. Hall-Ellis (PI) and Mary Ann Berry. Developed under the sponsorship of the Department of Library Science, College of Education and Applied Science, Sam Houston State University (Huntsville). Sam Houston State University Research Enhancement Fund, \$7,500 (1993-1994)

Electronic Mail Resource Sharing System: Management and Operation of the Iowa Computer-Assisted Network. State Library of Iowa, \$294,000 (1986-1993)

The Iowa Locator: A CD-ROM Resource Sharing Tool. State Library of Iowa, \$567,000 (1986-1992)

Statewide Database Development: An OCLC Tape Analysis To Determine Feasibility. State Library of South Dakota, \$15,000 (1987)

The Iowa Locator: A Feasibility Study. State Library of Iowa, \$50,000 (1986)

Electronic Mail Resource Sharing System: A Feasibility Study for Libraries in the State of Iowa. State Library of Iowa, \$5,000 (1985)

Access Pennsylvania: A Feasibility Study. State Library of Pennsylvania, \$50,000 (1984)

Automating Library Administrative and Management Tasks: Procurement and Distribution of Microcomputer Systems for District Library Centers in the Commonwealth of Pennsylvania. State Library of Pennsylvania, \$495,000 (1982)

Sharing Serial Titles Resources: Procurement and Distribution of Microfiche Readers for 550 Libraries in the Commonwealth of Pennsylvania. State Library of Pennsylvania, \$500,000 (1982)

Electronic Mail System: A Pilot Project for Libraries throughout the Commonwealth of Pennsylvania. State Library of Pennsylvania, \$125,000 (1982)

Literacy Program for Adults in Rural Upstate New York State: Program Outreach and Evaluation - Phase 3. Appalachian Regional Commission, \$50,000 (1981)

Database Building: A Cooperative Project of the Finger Lakes Library System (Ithaca), Four County Library System (Binghamton), and the Southern Tier Library System (Corning). New York State Library, \$450,000 (1980-1985)

Faces of the Southern Tier: A Professional Photographer-in-Residence. New York State National Endowment for the Humanities, \$25,000 (1980)

Literacy Program for Adults in Rural Upstate New York State: Program Implementation - Phase 2. Appalachian Regional Commission, \$50,000 (1980)

Small Business Resources Center: A Pilot Project for Rural Public Libraries. New York State Library, \$50,000 (1980)

Media Programming: A Professional Development Program for Public Librarians in Upstate New York: A Program in Allegheny, Chemung, Schuyler, Steuben, and Yates Counties. New York State Library, \$35,000 (1979)

Information and Library Resources for Inmates and Prisoners in Selected Upstate New York Facilities: A Cooperative Program in Allegheny, Chemung, Schuyler, Steuben, and Yates Counties. New York State Library, \$25,000 (1979)

Library Resources for Homebound Adults in Upstate New York: An Outreach Program in Allegheny, Chemung, Schuyler, Steuben, and Yates Counties. New York State Library, \$40,000 (1979)

Literacy Program for Adults in Rural Upstate New York State: Program Initiation and Establishment - Phase 1. Funded by the Appalachian Regional Commission. Awarded to the Corning (New York) Public Library, \$50,000 (1979)

Information Reference Services to Homebound Adults. New York State Library, \$31,000 (1978)

Books-By-Mail Services to Homebound Adults. New York State Library, \$31,000 (1978)

System Headquarters Services and Programs for Public Libraries in District 10. Funded through Library Services and Construction Act Title I. Texas State Library and Historical Commission, \$880,000 (1976)

County Library Development Grant for Atascosita County. Funded through Library Services and Construction Act Title I. Texas State Library and Historical Commission, \$15,000 (1976)

Spanish Language Materials Collection Development Program. Texas State Library and Historical Commission, \$40,000 (1975)

Establishment of System Headquarters for Alamo Regional Library System (District 10) Headquartered at the San Antonio (Texas) Public Library. Texas State Library and Historical Commission, \$800,000 (1975)

SELECTED CONSULTANTSHIPS

Project Strategic Planning & Funding Proposal Development

Walden University, 2015.

Pikes Peak Library District, 2014.

Douglas County Public Libraries, 2011-2012.

Denver School for Science and Technology, 2008-2011.

Johnson & Wales University, Denver Campus, 2007-2009.

Challenges, Choices, and Images K-12 Charter School, Denver Public Schools, 2007.

Denver Medical Library, Inc., 2006-2010.

Bemis Public Library (Littleton), Ergonomic Design and Facilities Enhancement Consultant, 2003.

Curtis Park Community Center (Denver), Community Technology Center Evaluation and Proposal Development Consultant, 2003.

Colorado Community Based Research Network (Denver), Funding Research Associate, 2002-

Our Lady of the Rosary Academy (Edgewater), Learning Resource Center Development Project Consultant, 2001-

University of Southern Colorado (Pueblo). Technology Integration and Curriculum Enhancement into Higher Education Learning Environment. Proposal Development Consultant, 2000.

Jefferson County Library System (Lakewood), 1999-2000.

Southeastern BOCES (Lamar, CO). Distance Learning Curriculum Content Development Project. Proposal Development Consultant, 1998-2004.

Cheyenne Mountain School District 12 (Colorado Springs, CO). Technology Integration into Elementary Writing Curriculum Project. Proposal Development Consultant, 1998.

Telecommunications Infrastructure Fund Board Round #2 Application, 1997. Technical assistance to the following: La Villa (Texas) Independent School District; Mirando City (Texas) Independent School District; Monte Alto (Texas) Independent School District; San Isidro (Texas) Independent School District.

Telecommunications Infrastructure Fund Board Round #1, 1996. Technical assistance to the following: Brownsville (Texas) Independent School District; Donna (Texas) Independent School District; Edinburg (Texas) Consolidated Independent School District; Harlingen (Texas) Consolidated Independent School District; Jim Hogg County Independent School District (Hebbronville, Texas); La Feria (Texas) Independent School District; La Joya (Texas) Independent School District; La Villa (Texas) Independent School District; Los Fresnos (Texas) Consolidated Independent School District; Progreso (Texas) Independent School District; Raymondville (Texas) Independent School District; Rio Hondo (Texas) Independent School District; San Benito (Texas) Independent School District; Sharyland Independent School District (Mission, Texas); Weslaco (Texas) Independent School District; Zapata (Texas) County Independent School District.

South Texas Community College (McAllen). Strategy Development to Meet the Technology Instructional Needs for Vocational, School-To-Work and Academic Programs, 1994-2000. Development Consultant.

Donna (Texas) Independent School District. Planning for the Infusion of Technology in Middle Schools Serving High At-Risk Students, 1994-1995. Research Associate.

Pettus (Texas) Independent School District. Planning for District-wide Automation in School Library Media Centers: Preparation of Data, and CD-ROM Hardware/Software Configuration Evaluation, 1994. Principal Investigator.

Fort Bend Independent School District (Sugar Land, TX). Planning for District-wide Automation in School Library Media Centers, Preparation of Data, and CD-ROM Hardware/Software Configuration Evaluation, 1994-1995. Principal Investigator.

Northern Waters Library Services (Ashland, WI). Professional Consulting Services to Make Recommendations on the Development of System-Wide Efforts of the Northern Waters Library Service, 1988-1989. Research Associate.

State Library of Iowa (Des Moines). The Iowa Locator Compact Disc to Support Multi-Type Libraries Resource Sharing including Database Design, Building, Production, and Distribution, 1986-1991. Project Director.

State Library of Iowa (Des Moines). Iowa Computer-Assisted Network Development, Enhancement, and Operation, 1985-1992. Technical Director.

State Library of South Dakota (Pierre). Statistical Sampling and Analysis of Multi-Institutional OCLC Archive Tape for Statewide Online Database Building, 1985-1986. Research Associate.

District of Columbia Public Library (Washington, DC). Planning Document for the Retrospective Conversion of Bibliographic Records and Automation Issues in the 1990's, 1984-1985. Research Associate.

State Library of Pennsylvania (Harrisburg). Database Development for High School Libraries, 1984-1985. Research Associate.

MINITEX (Minneapolis, MN). Workshops for Retrospective Conversion, Bar Coding, Library Statistics, and OCLC Serials Format, 1985. Presenter and Research Associate.

ABC Film Consortium (Altoona, Bellefonte, Johnstown, PA). Database Building, System Design, and Implementation of Online Film Booking System, 1983-1985. Database Manager.

Library Automation -- System Design & Implementation

Douglas County Library District (Castle Rock, CO). Library Automation Technical and System Performance Specifications, 2001.

Pharr-San Juan-Alamo Independent School District (Pharr, TX). Library Automation Technical and System Performance Specifications, 1997. Project Development Consultant.

Harlingen (Texas) Independent School District. Planning for District-wide Automation in Junior High School Library Media Centers: Preparation of Data, and CD-ROM Hardware/Software Configuration Evaluation, 1996. Principal Investigator.

Sharyland (Texas) Independent School District. Design and Construction of New Elementary School Library and Technology Resources Center, 1995-1996. Principal Investigator.

South Texas Independent School District (Mercedes, TX). Design and Construction of a New High School Library and Technology Resources Center, 1995-1996. Principal Investigator.

Citizens' Library (Washington, PA). Online Community Resources Files: Design and Implementation, 1984. Research Associate.

Altoona (Pennsylvania) Hospital. Integrated Online System Upgrade Study, 1984. Research Associate.

State Library of South Dakota (Pierre). Automation Plan and State Database Development, 1982-1983. Principal Investigator.

State Library of Pennsylvania (Harrisburg). COM Production and Preparation of the Technical Specifications Document, Procurement, and Distribution of Microcomputers in the Commonwealth of Pennsylvania, 1983-1984. Research Associate.

Altoona (Pennsylvania) Area Public Library. Integrated System (Circulation/Online Catalog) Study, 1982-1983. Principal Investigator.

COPSCAULD (Council of Pennsylvania State College and University Library Directors, Edinboro, PA). Design of Online Media Catalog, 1982. Principal Investigator.

Erie (Pennsylvania) County Library System. Operations Research and Design for Automated Circulation, Hardware Upgrade and Re-Retrospective Conversion, 1982. Research Associate.

Michigan Library Consortium (Lansing, MI). Tape Management System Design and Implementation, 1982-1984. Research Associate.

State Library of Pennsylvania (Harrisburg). Preparation of the Technical Specifications Document, Procurement and Distribution of Microfiche Readers in the Commonwealth of Pennsylvania, 1982. Research Associate.

Community College of Allegheny County, Allegheny Campus (Pittsburgh, PA). Integrated Systems Study, 1981. Principal Investigator.

Community College of Allegheny County, South Campus (West Mifflin, PA). Retrospective Conversion Training Program for Handicapped Students, 1981. Technical Director.

Southern Tier Library System (Corning, NY). OCLC Acquisitions Subsystem Evaluation, 1981. Principal Investigator.

South Central Reference and Research Council (Ithaca, NY). South Central Regional Delivery System, 1980. Principal Investigator.

Southern Tier Library System (Corning, NY). Newspapers on Microfilm in the Chemung-Southern Tier Library System, 1979-1981. Principal Investigator.

Cataloging & Bibliographic Database Building

Challenges, Choices, and Images K-12 Charter School, Denver Public Schools, 2007.

Denver Medical Library, Inc., 2006-2010.

Ricks Gifted and Talented School Library, 2005-

American Humane Society (Englewood), 2004-2006.

Fisher Early Learning Center Library, 2004-

Colorado Community Based Research Network (Denver), 2004-
Boulder Valley School District (Boulder), 2002-2003.

Douglas Public Library District (Castle Rock), 2001-2002.

Bibliographic Center for Research, Inc. (Denver). Original Cataloging, 2001-2003 & 1992-1993. Professional Cataloger. Libraries include Arapahoe Library District (Centennial); Clarke College (Clarke, IA); Kaiser Permanente Center for Health Research (Portland, KS); Douglas County Library System (Carson City, NV); Grinnell College (Grinnell, IA); Kansas State University (Manhattan, KS); Kansas State Library (Topeka, KS); McPherson College (McPherson, KS); Newman University (Wichita, KS); Montana Technical University (Helena, MT); Montana State Library (Helena, MT); University of Texas Southwest Medical Center Library (Dallas, TX); Community College of Southern Nevada (Las Vegas, NV); Pikes Peak Library District (Colorado Springs); Mesa Community College (Grand Junction); Coe College (Cedar Rapids, IA); Briar Cliff College (Sioux City, IA); Tri-Care Health Systems (Aurora); The Penrose-St. Francis Healthcare System (Colorado Springs); Westminster Public Library (Westminster); Lutheran Medical Center Medical Library (Wheat Ridge); American Heritage Center, University of Wyoming (Laramie, WY); National Wildlife Research Center Library (Lakewood); University of Colorado Health Sciences Center, Denison Memorial Library (Denver); Water Resources Library, Denver District Office, Bureau of Land Management (Lakewood); Mesa State Community College Learning Resources Center (Pueblo); Front Range Community College Learning Resources Center (Westminster).

Colorado Historical Society Library (Denver). Original Cataloging of Serials for Multi-Institutional Union Listing Project, 1993. Technical Services Associate. Institutional partners: Denver Art Museum, Denver Museum of Natural History Library, and Denver Botanical Gardens Library.

Arapahoe Library District (Centennial). Original Cataloging of Major Media, 1991.

Original Cataloging Projects: Davis and Elkins College (Elkins, WV), 1989-1990; Waldorf College (Forest City, IA), 1989-1990; Kennametal Corporation (Latrobe, PA), 1984-1985; Pennsylvania Public Libraries Film Center (Harrisburg), 1982-1985.

Retrospective Conversion Projects: North Central Regional Library Service (Mason City, IA), 1987-1988; Southeastern Library Services (Davenport, IA), 1986-1987; Virginia Theological Seminary (Alexandria), 1984-1985; California University of Pennsylvania (California, PA), 1984-1985; Kennametal Corporation (Latrobe, PA), 1984-1985; West Virginia University (Morgantown), 1983-1985; Altoona Area Public Library (Altoona, PA), 1983-1984; George Washington University (Washington, DC), 1983-1984; Indiana University of Pennsylvania (Indiana, PA), 1983-1985; Health Education Center (Pittsburgh), 1983-1984; Central Pennsylvania District Library Center (Bellefonte, PA), 1982-1985; Duquesne University Law School Library (Pittsburgh), 1982-1983; Allegheny County Law Library (Pittsburgh), 1982-1984; Calgon Technical Information Center (Pittsburgh), 1982; Dow Corning Corporation, Technical Information Center (Midland, MI), 1982-1983; Tri-System Public Library Retrospective Conversion Project (Binghamton, Corning, and Ithaca, NY), 1978-1981, Technical Project Director.

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Attachment 1A

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Yong Liu, Yongxiang Su, Tianlin Zhu,
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Informative Abstract

This book is compiled based on principles of basic theory, prominent practicability and comprehensiveness, and easy operability. The content relates to basic chemical industry of sulfuric acid industry, chlor-alkali industry, soda ash industry, synthetic ammonia and nitric acid industry, chemical fertilizer industry, etc., and inorganic salt industry of fluoride salt, chromium salt, phosphate, aluminium salt, imine, sodium percarbonate, hydrogen peroxide, silicate of soda, etc. Product performances, production raw materials, processes, production devices, subsequent products, etc. are introduced in detail. This book is suitable for students majored in inorganic chemical engineering in vocational university as a teaching material and also researchers and factory technicians as a reference.

(Shan) Xindeng007

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Foreword

As another form of higher education, vocational university has been valued and vigorously promoted by the State Council and the Ministry of Education. It is an established higher education system equal to ordinary higher education and an important reform on the education system of our country that focuses on theory over practice and where teaching and production practice are disconnected. At present, the ministry of education focuses on supporting 4 national exemplary vocational universities and provides that the vocational universities should make corresponding reforms on teaching materials, teaching methods, experiments, and examination methods to enhance training of practical ability of students and make up for defects of ordinary higher education. Since original teaching materials of ordinary universities are far from being able to meet requirements of the teaching reform in vocational universities, the reform on teaching materials is a core of reforms on vocational higher education. Therefore, we decide to compile “Practical Inorganic Chemical Technology”. The teaching material has characteristics of sufficient theory, emphatic practicality, prominent technology, convenient operation, and enlarged coverage of content, etc. to highlight training of ability and technology. It shortens a gap between book knowledge and production practicality, deletes some unnecessary theoretical derivations, and increases newly developed products and technologies. Besides, it has relatively high reference value for students in vocational universities and adult education, researchers, and factory technicians.

The whole book is divided into nine chapters. Dexue Fu from Jiaozuo University, Henan participated in the compilation of chapters 1, 4, 5, and 9, Changchun Liu participated in the compilation of chapter 2, Jingcheng Tian participated in the compilation of chapters 5 and 6, Longdao Wang participated in the compilation of chapter 9, and Zhansheng Cheng participated in the compilation of chapter 6, Xiangyu Shi participated in the compilation of chapters 3 and 7, Chunli Xing participated in the compilation of chapters 6 and 7, Cunhong Li participated in the compilation of chapters 5 and 8, Tianlin Zhu participated in the compilation of chapters 3 and 8, Yong Liu participated in the compilation of chapters 3 and 4, Li Huo participated in the compilation of chapters 2 and 8, Yongxiang Su participated in the compilation of chapters 2 and 5, Yanqin Huang from Pingyuan University, Henan participated in the compilation of chapters 6 and 7, and Shaohong Xu participated in the compilation of chapters 2 and 8, and the whole book is examined and approved by Dexue Fu.

Due to the limited abilities of the editors, there are definitely still shortcomings and readers are welcome to make comments.

Compiling group of “Practical Inorganic Chemical Technology”

October 1997

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7.1.4 Overview on Chinese Soda Ash Industry

Before 1949, there were only two soda ash factories using an ammonia soda process in Tanggu District of Tianjin, and Dalian with a maximum output of 101 kt (in 1940). After the founding of the People's Republic of China, in order to meet demands of industrial development, soda ash production has been greatly developed. In addition to restoration and expansion of the two original soda ash factories, there are also dozens of small and medium-sized soda ash factories are designed and constructed in Zigong of Sichuan, Qingdao, Yingcheng of Hubei, Longshan of Hangzhou, etc. The output has grown from 88 kt in 1949 to 2.37 Mt in 1987 (not including Taiwan Province), ranking third in the world. The consumption of main raw materials is also reduced and processes and devices are greatly improved. Although our country's self-developed soda ash joint production is later in production than Japan, its technical level is not much different. At present, sea salt is mainly used as a raw material. Besides, there is still a certain amount of trona in the mainland. Over the years, certain achievements have been made in scientific researches on processing and utilization of a trona mine in Chaganlimennuoer, Inner Mongolia, a trona lake in Dabusu, Jilin, and a trona mine in Wucheng, Henan. In recent years, more than 20 underground rock salt resources have been discovered in coastal provinces. For example, the rock salt reserves are quite considerable in Huai'an, Jiangsu Province. If the brine is used to prepare soda ash, it will reduce production costs and improve production of soda ash.

Although remarkable achievements are made in our country in various aspects over the past 40 years, there is still a big gap between the national economy's demand for soda ash industry and the world's average level of soda ash of 7.5 kg per person. Since the average amount of soda ash produced in 1987 of our country is only 2.2 kg per person, the self-produced soda ash cannot meet the consumption requirement and a considerable amount of soda ash still needs to be imported from abroad. In order to rapidly change the situation of shortage of soda ash supply and partial dependence on import, a large soda ash factory with an annual production of 0.6 Mt has been newly built in Weifang in Shandong, Tangshan in Hebei, and Lianyungang in Jiangsu in our country. In addition, a main difference in soda ash industrial technology between our country and advanced countries is high energy consumption. The energy consumption of unit of products in the same process is about 25%-33% higher. The energy consumption index of 1 t of soda ash produced in the advanced countries is 13 GJ by an ammonia soda process and 9 GJ by a soda ash joint production process.

7.1.5 Main raw material for preparing soda ash-raw salt

Raw salt is a main raw material for preparing soda ash and mainly from sea salt, rock salt, and natural brine.

1. Sea salt Various salts are dissolved in seawater, mainly NaCl. The seawater is introduced into a salt pan and sun-dried to obtain sea salt whose composition varies due to different places and sun-drying conditions. The following is chemical components of sea salt in a certain place (wt%):

NaCl.....	89.93	MgBr ₂	0.01
CaSO ₄	0.48	KCl.....	0.22
MgSO ₄	0.57	Moisture	6.48
MgCl ₂	0.52	Others	0.27

2. Rock salt Natural sodium chloride in the form of deposits still existing in the strata is called rock salt. A method of injection and melting is commonly used for mining and the obtained brine has different components. Here is an example:

NaCl 297.84 kg/m³; CaSO₄ 4.77 kg/m³; MgCl₂ 1.68 kg/m³;
MgSO₄ 0.76 kg/m³; and Relative density 1.199 (23°C)

3. Natural brine The Natural brine generally contains more than 12% of NaCl and impurities such as KCl, NH₄Cl, CaSO₄, MgCl₂, etc.

At present, my country's sea salt production is the largest. Due to convenient transportation and proximity to soda ash factories, the cost is the lowest and the sea salt is an important source of raw salt.

7.2 Preparation of Soda Ash by ammonia soda Process

7.2.1 Overview on production by ammonia soda process

1. Production process Soda ash consists of 98%-99% by weight of Na₂CO₃. Soda ash is prepared from edible salt (active ingredient NaCl) and limestone as follows:



however, the soda ash cannot be directly prepared according to the route and can only be realized through an intermediate product of NH_4HCO_3 and NaHCO_3 . The more expensive ammonia, NH_3 , only acts as a medium here. It is not consumed in the production process and can be continuously recycled.

Since a NH_3 circulation system is involved in a main production process, the production process of the soda ash is more complicated in equipment and operation. To maintain a balance of original production links, it is necessary to operate carefully and have rich production experience. From an economical view, every effort must be made to keep the ammonia consumption as low as possible.

Figure 7-1 is a flow diagram of production of soda ash by an ammonia soda process.

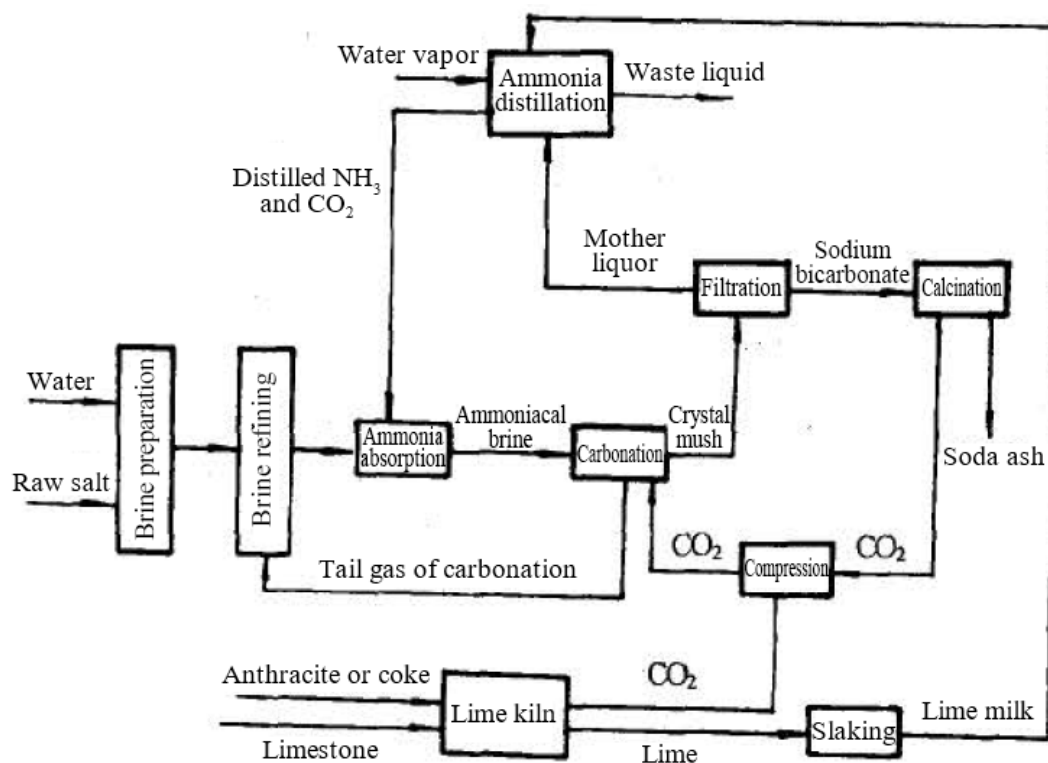
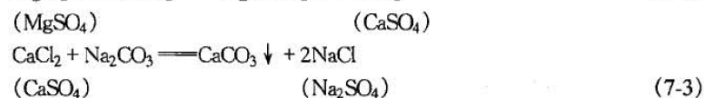
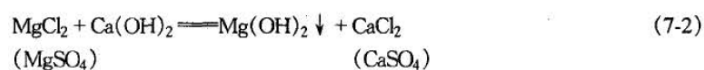


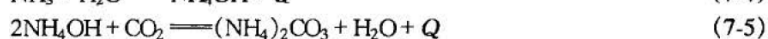
Figure 7-1 Flow diagram of ammonia soda process

2. Production of soda ash NaCl enters the production process in a form of an aqueous solution. Brine can be prepared from solid NaCl or natural brine can be used.

In order to avoid scaling of equipment and pipelines, Na_2CO_3 and $\text{Ca}(\text{OH})_2$ are often added to a brine refining device to precipitate calcium and magnesium.

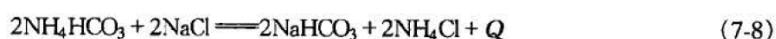
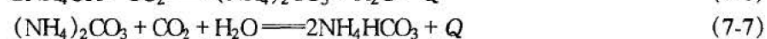
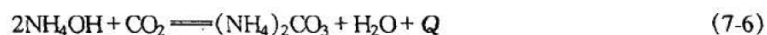


The brine enters an ammonia absorption tower to absorb the required amount of NH_3 and also absorbs a small amount of CO_2 at the same time.



The reaction heat of the two exothermic reactions is conducted in a staged manner for cooling.

Ammoniacal brine with a low carbonation degree is cooled and then subjected to a carbonation process, and enters a tower here, and CO_2 is introduced.



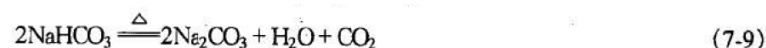
A part of CO₂ comes from a lime kiln; and a part comes from calcination of NaHCO₃. NaHCO₃ is seldom dissolved in mother liquor of soda ash preparation, such that it is precipitated in a form of crystals. In an actual production, the precipitation amount of NaHCO₃ is equivalent to 70%-75% of the amount of Na brought in by NaCl, and the remaining Na remains in the solution and cannot be used in a subsequent process.

The absorption of CO₂ and the production of NaHCO₃ are also exothermic processes, such that the carbonation tower should be fully cooled.

The NaHCO₃ crystals suspended in taking-out liquid of the carbonation tower are subjected to a solid-liquid separation by a rotary vacuum filter.

The air sucked in from the filter contacts with the mother liquor to bring out NH₃. The ammonia-containing air is washed with water in an ammonia purification tower and the ammonia is recovered into the system.

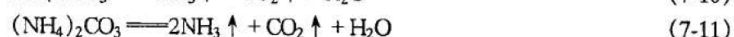
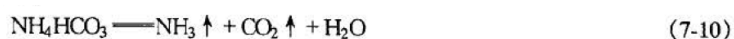
A filter cake containing NaHCO₃ is calcined to obtain final products Na₂CO₃ and CO₂:



At the same time, a small amount of NH₃ is driven out and the part of ammonia is brought to the calcination process by the remaining mother liquor adhering to the crystals of the filter cake.

3. Recovery of NH₃ A large amount of NH₃ remains in the mother liquor in a form of NH₄Cl, NH₄HCO₃ and (NH₄)₂CO₃. The NH₃ in the mother liquor must be distilled out and returned for absorption. The ammonia is driven out by steam in a gas-liquid counterflow device.

In a mother liquor preheating section of an ammonia distillation tower, gas passes through a heat exchange surface to preheat the mother liquor and some CO₂ escapes. In the preheating section, the gas directly contacts with the liquid. Finally, almost all CO₂ in the mother liquor is driven out and a small amount of NH₃ is converted from liquid to gas with CO₂. The reaction is as follows:



Then the mother liquor enters a preliher and Ca(OH)₂ is added to decompose NH₄Cl.



Finally, in a distillation section, steam is used to drive out NH₃ until only a trace amount of NH₃ remains in the solution. A solution at an end point from the distillation section enters a flasher and is discharged after cooled slightly.

The gas containing NH₃ and CO₂ of a very high concentration from the ammonia distillation tower passes through a condenser to an absorption process.

4. Carbon dioxide

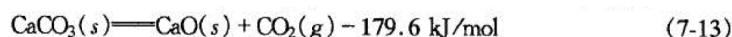
The gas from calcination, and absorption and washing contains approximately less than half the amount of CO₂ required to form NaHCO₃. The remaining CO₂ comes from a lime kiln. Calcium carbonate is decomposed into CO₂ and CaO in the lime kiln. Kiln gas is washed and dedusted with water in a washing tower, sulfur compounds are removed, and the gas is cooled and then sent to the carbonation tower by a gas compressor together with CO₂ gas in the production process.

7.2.2 Calcination of limestone and slaking

In the brine refining and ammonia recovery, a large amount of lime milk is required. The carbonation process requires a large amount of CO₂ gas, such that limestone is calcined to produce CO₂ and lime, and then the lime slakes to produce lime milk, which has become an indispensable preparation process in the production by the ammonia soda process.

1. Calcination of limestone

(1) Basic principle of calcination of limestone The main component of the limestone is CaCO₃ with the better content about 95%. In addition, there are still 2%-4% of MgCO₃ and a small amount of SiO₂, Fe₂O₃, Al₂O₃, etc. The main reaction in the calcination process is:



According to thermodynamic data, when a partial pressure of CO₂ reaches 0.1 MPa, the theoretical decomposition temperature of the limestone is 1,180 K.

The actual operating temperature is higher than the above theoretical decomposition temperature, and therefore, the decomposition rate of the limestone is slow at 1,180 K. The decomposition rate of ore is represented by a speed (R) that a reaction surface (an interface between produced CaO and internal CaCO_3) advances to the interior. The speed is not related with the size of the ore and has a relationship with a temperature t ($^{\circ}\text{C}$) as:

$$\lg R = 0.003145t - 3.3085 \text{ cm/h} \quad (7-14)$$

It can be seen from formula (7-14) that calcination time can be shortened by high temperature.

At a certain temperature, the calcination time required for ores of different sizes is shown in Figure 7-2. However, raising the temperature is also limited by a series of factors. If the temperature is too high, a molten or semi-molten state may occur, wall hanging or nodulation may occur, and the ore will become solid “over burnt lime” not easy for slaking. Practice has proved that the temperature of burning limestone is generally controlled within a range of 940-1,200 $^{\circ}\text{C}$.

The calcination of the limestone is an endothermic reaction. Heat is usually supplied by burning coke or anthracite (also gas or oil). Fuel is required to be completely burned in the kiln to provide the most heat. However, sometimes due to insufficient oxygen or local hypoxia caused by nodules in the kiln, the fuel cannot be completely burned and a small amount of CO is produced. Therefore, it is necessary to strictly control the amount of air in the operation to control the content of CO in the kiln gas to be less than 0.6% and the content of O_2 to be less than 0.3%.

There are two sources of CO_2 in the kiln gas: one from decomposition of CaCO_3 ; and the other from a product of fuel combustion. The former is pure CO_2 gas; and the latter is mixed gas of CO_2 and N_2 . Theoretically, when pure carbon is burned, the CO_2 in the gas can reach 21%, but the concentration of the CO_2 can be reduced due to excess oxygen or production of CO . It can be seen that burning limestone uses less fuel, which not only saves fuel, but also improves the concentration of CO_2 in the kiln gas. But enough heat must be provided for the decomposition reaction. Now the number of kg of fuel in 100 kg of limestone is called “coking rate” and expressed by symbol F , then

$$\text{Concentration of } \text{CO}_2 \text{ in kiln gas} = \left[\frac{\frac{\text{CaCO}_3 \%}{100} + \frac{\text{MgCO}_3 \%}{84.3} + \frac{\text{C}\%}{12} \times F}{\frac{\text{CaCO}_3 \%}{100} + \frac{\text{MgCO}_3 \%}{84.3} + \frac{\text{C}\%}{12} \times F \times \frac{1}{0.21}} \right] \times 100 \quad (7-15)$$

In the formula, $\text{CaCO}_3\%$ and $\text{MgCO}_3\%$ -percentages of CaCO_3 and MgCO_3 in limestone respectively;

$\text{C}\%$ -percentage of fixed carbon in fuel; and

0.21-mole fraction of oxygen in the air.

Theoretically, the concentration of CO_2 in the kiln gas is 44.2%, but generally around 40%. Therefore, the produced kiln gas must be exported in time, otherwise the reaction will be affected. During the production, the kiln gas is purified, cooled and continuously pumped out by a compressor to continuously decompose the limestone.

2. Lime kiln and its operation At present, limestone is mostly calcined by a mixing vertical shaft kiln. The kiln has advantages of large production capacity, fully mechanized loading and unloading, high concentration of kiln gas, high heat utilization rate, and good quality of lime.

The structural schematic diagram of the lime kiln is shown in Figure 7-3.

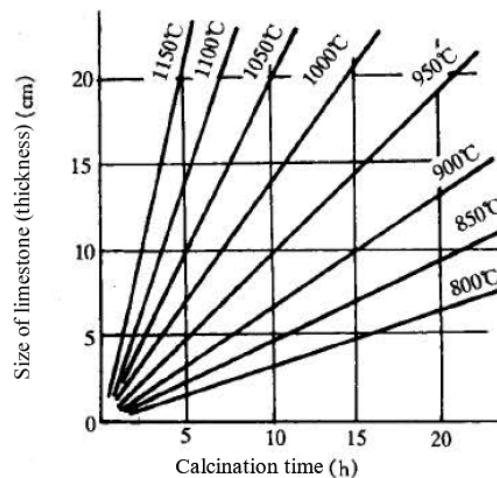


Figure 7-2 Relationship between limestone size and calcination temperature and calcination time

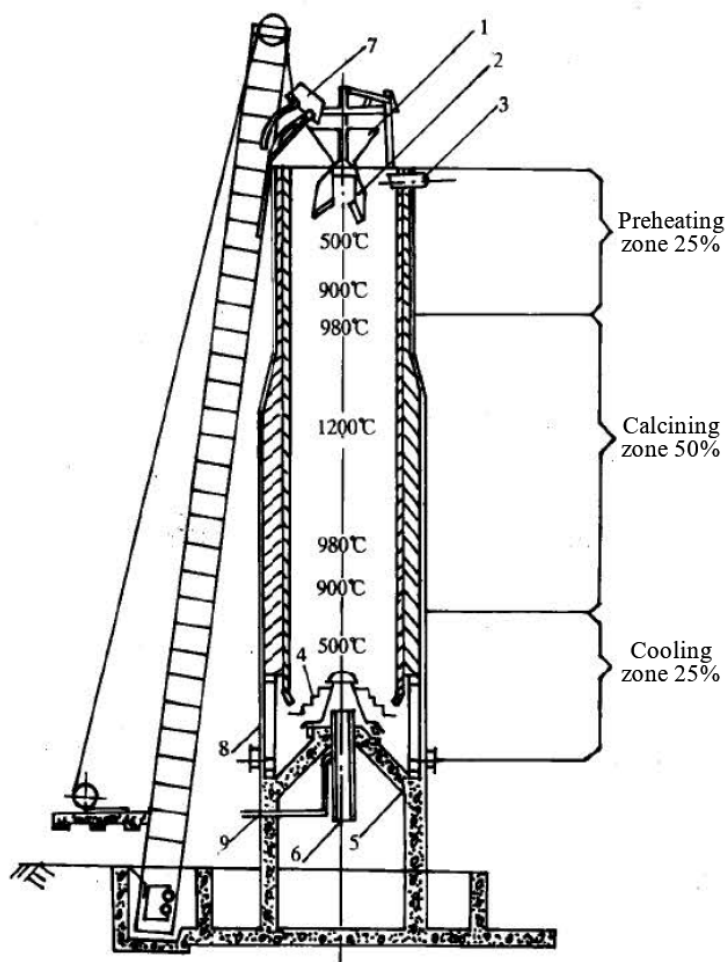


Figure 7-3 Schematic diagram of lime kiln

1-funnel; 2-limestone distributor; 3-air outlet; 4-lime output rotary table; 5-periphery air duct; 6-center air duct; 7-limestone lifting tank; 8-lime outlet; and 9-adaptor tube of draftmeter

The kiln body is made of ordinary bricks or steel plates, with refractory bricks inside. A thermal insulation material is filled between the two layers to reduce heat loss. The kiln is divided into three zones from the top to the bottom: a preheating zone, a calcining zone, and a cooling zone. The preheating zone is located at an upper part of the kiln, accounting for about a quarter of the total height. The preheating zone functions to use hot kiln gas rising from the calcining zone to preheat and dry limestone and fuel to recover waste heat of the kiln gas and improve thermal efficiency. The calcining zone is located in a middle part of the kiln. The preheated mixed materials are calcined here to decompose the limestone. To avoid nodulation by over-burning, the temperature in the calcining zone should not exceed 1,350°C. The cooling zone is located in a lower part of the kiln, accounting for about a quarter of the effective height of the kiln. The cooling zone mainly functions to preheat the air entering the kiln to cool the hot lime, such that the heat is recovered and the kiln grate is maintained.

The proportion of ingredients, the size of blocks, the air pressure and air volume, and the speed of feeding and discharging are main conditions for maintaining the normal operations of the lime kiln.

The equilibrium state in the kiln is easily disturbed by operational errors or breaks, and thus measures must be taken to return to normal as soon as possible. Under the premise that the proportion of the amount of the limestone and coke is appropriate, the following measures should be taken:

Whether the position of the calcining zone is too low can be known from too high lime temperature. The position of the calcining zone can be increased by increasing the air blowing amount.

Whether the position of the calcining zone is too high can be known from too high air-out temperature. The measures are more complicated. Lime discharge must be enhanced while the air volume is reduced as much as possible until the calcining zone is mechanically restored to its normal position. Then the kiln is filled up by a quick feeding and the normal air flow is restored.

When the calcining zone is extended (both upper and lower temperatures are high), the lower limit of the calcining zone is first moved upward by air intake, then the lime discharge must be enhanced, and the kiln is filled by feeding, such that the calcining zone shrinks to the middle. Under the normal condition in the reaction zone where a coke-stone ratio has been adjusted, only the air volume is adjusted to maintain the normal state of the kiln. Under the normal condition, the gas in the kiln is controlled to be neutral or slightly reducing gas.

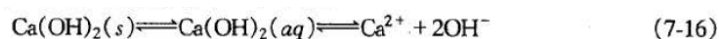
It is most important is to carefully adjust the air volume. In order to avoid the inlet of the air, the whole kiln needs to maintain a positive pressure which is formed by a blower sending the air into the kiln from a lower part.

Since dust is easily produced from the lime, dust prevention of all lime treatment devices should be paid attention to and the devices should be frequently maintained.

If dust raising is unavoidable, the dust-containing air can be drawn out and washed with water, and the washing water can be used for lime slaking.

2. Lime slaking

Ca(OH)_2 , instead of CaO , is used for brine refining and ammonia distillation. CaO can be converted into Ca(OH)_2 by slaking using an appropriate amount of water. But the solubility of the Ca(OH)_2 is very low and decreases with the increase of temperature. Besides, powdered slaked lime is very inconvenient to use, such that its suspension, also called lime milk, is used in the production. The following balance exists:



The lime milk is relatively thick and thus more favorable for production. But its viscosity increases with the thickness. If the lime milk is too thick, it will settle and block the pipelines and equipment. The generally used lime milk contains about 160-220 tt^① of active CaO and has the relative density about 1.27.

The dispersion degree of suspended particles in the lime milk is very important. When the particles are small, they are easy to be made into a uniform milky substance not easy to sink, which is convenient for transportation and use. The factors affecting the size of the suspended particles are purity of lime, water quantity, water temperature, and stirring strength. Too many impurities in lime or over-burning will reduce the quality of the lime milk. The high temperature of water for slaking can accelerate the slaking and form a powder with a finer suspension particle size. Generally, warm water at 65-80°C is suitable for the production.

Flow diagram of lime slaking system is shown in Figure 7-4.

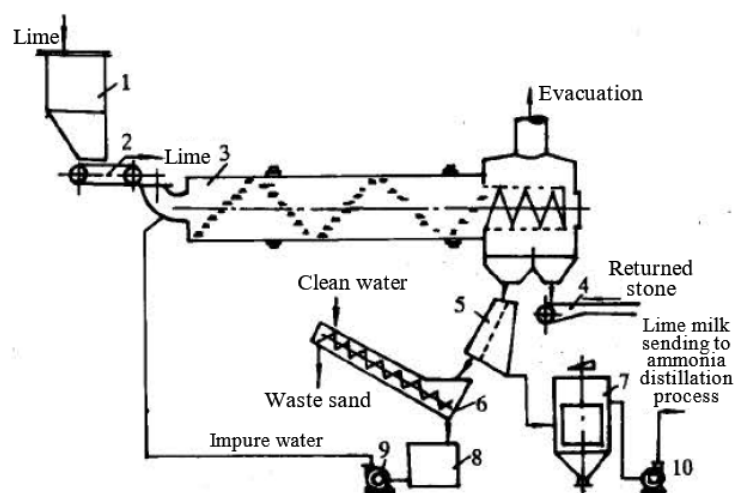


Figure 7-4 Schematic diagram of lime slaking process and lime slaking machine

1-lime bin; 2-chain plate machine; 3-lime slaking machine; 4-returned stone belt; 5-vibrating sieve; 6-spiral sand washing machine; 7-lime milk bucket; 8-impure water bucket; 9-impure water pump; and 10-lime milk pump

The lime slaking machine (slaking machine) is a horizontal rotary cylinder slightly inclined to one end of an outlet (about

① A unit of concentration is commonly used in soda ash factories and called "titer". Symbols can be tt or ti. $1 \text{ tt} = \frac{1}{20} \text{ mol/L}$. This is the meaning of "tt" in the following chapters.

0.5 degrees). Lime and water are added from one end to be mixed and reacted with each other. The cylinder is equipped with a number of spirally arranged shoveling plates which push the solid mixture towards the other end when rotate. There are two layers of sieves with different apertures at a tail. The produced lime milk flows out from sieve holes and enters a lime milk bucket through a vibrating sieve. The remaining under-burnt or over-burnt lime flows out from the sieve. The large blocks of under-burnt lime can be returned to the kiln to be reused and are called returned stone. The small blocks from the vibrating sieve are called waste sand, and are discharged and discarded.

7.2.3 Brine refining

1. Objective of brine refining

Converted Na in soda ash production is provided by edible salt. A nearly saturated NaCl aqueous solution is introduced into a system as crude brine. The natural brine is often found in nature and pumped from a deep part of a well. The crude brine can also be prepared by dissolving solid salt with water. For example, the saturated crude brine can be prepared using sea salt. The approximate composition (kg/m^3) of the crude brine is as follows:

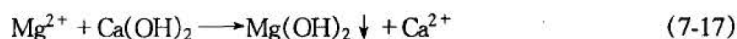
NaCl 300.4; CuSO_4 4.81; CaCl_2 0.8; and MgCl 0.35

Although the amount of calcium salts and magnesium salts contained in the crude brine is not large, they can be reacted with NH_3 and CO_2 to form a precipitate of double salts in each subsequent process, which causes scaling or even blocking of equipment and pipelines, and will increase loss of raw salt and ammonia. These impurities will also be mixed into sodium bicarbonate, which will eventually affect the quality of the soda ash. Therefore, a pre-refining measure is used in the production to remove these impurities. Generally, it is required that the accuracy of removing calcium and magnesium is above 99%.

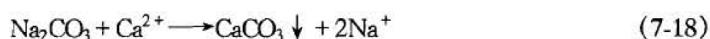
2. Method for brine refining

(1) Lime and soda ash method

Magnesium is precipitated with $\text{Ca}(\text{OH})_2$ (lime milk) and calcium with NaCO_3 :



to obtain a first brine and a first sludge.

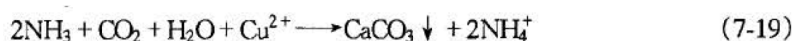


to obtain a second brine and a second sludge.

$\text{Mg}(\text{OH})_2$ and CaCO_3 are precipitated out as a precipitate, but CaCl_2 , NaCl and Na_2SO_4 are still dissolved in the brine. The Na^+ brought in with CaCO_3 also exists in a form for producing soda ash. But in a sodium bicarbonate making tower, only a part of this Na^+ is converted into NaCO_3 due to limitation of a conversion rate. The diameter of the CaCO_3 crystals is 1-10 μm , while the diameter of the produced $\text{Mg}(\text{OH})_2$ crystals is only a few μm . A single $\text{Mg}(\text{OH})_2$ crystal cannot settle at all, while the sedimentation velocity of the CaCO_3 crystals in the brine at 15°C is 0.1 m/h or below. The CuCO_3 crystals are added into the $\text{Mg}(\text{OH})_2$ crystals which can grow into aggregates with a very fast sedimentation velocity, and therefore a clear precipitated sludge interface can be obtained in a clarifying device. In the production process, it is the reason that the second sludge is returned to a primary refining device to accelerate the coagulation and sinking of the precipitate.

(2) Lime-tower gas method (lime-ammonium carbonate method)

The “first brine” is treated with tail gas containing NH_3 and CO_2 at a top of the carbonation tower to precipitate CaCO_3 with very little solubility.



Mg^{2+} is removed using the same above method.

In addition, polyacrylamide (PAM) can also be used. Due to its large molecule and polar group, the polyacrylamide is easy to adsorb precipitated particles and can “bridge” particles to form flocs with a spatial network structure, which is quite effective to shorten the settling time and improve the production capacity of the equipment. The total chloride ion concentration (represented by the symbol T_{Cl}) in the second brine prepared by the production factory generally reaches about 105 tt.

The brine refining process of the lime-tower gas method is shown in Figure 7-5.

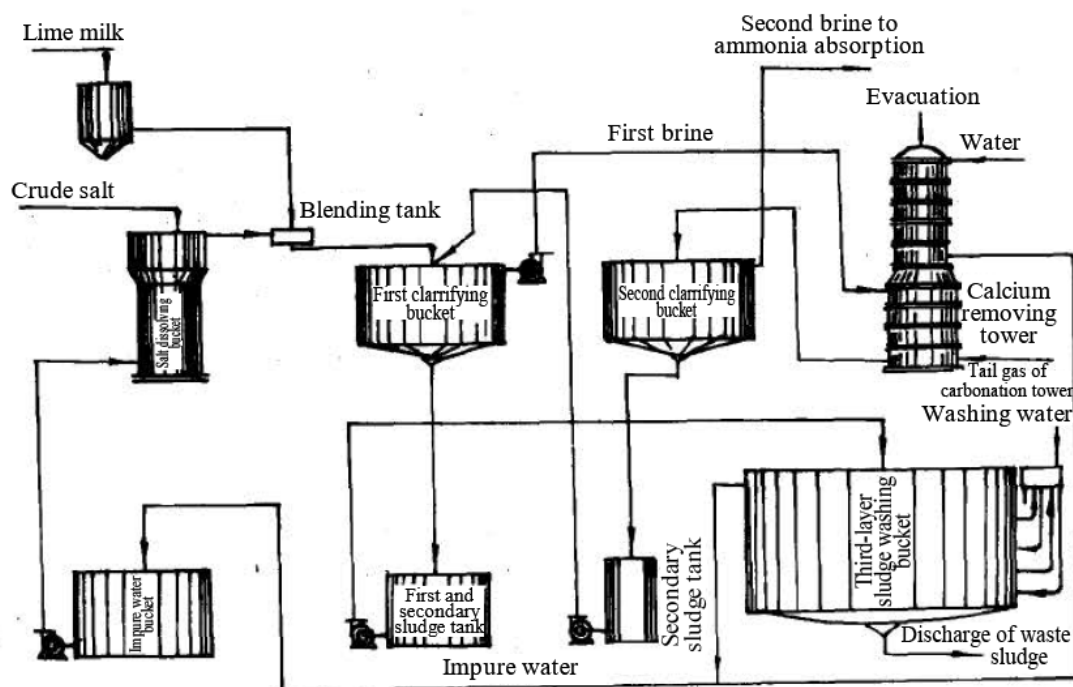


Figure 7-5 Flow diagram of brine refining

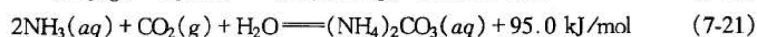
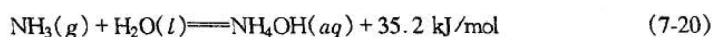
7.2.4 Ammonia absorption by brine

1. Theory of absorption process

Ammonia absorption by brine is to prepare ammoniacal brine and enable it to reach the concentration required for carbonation (T_{Cl} 89-94 tt, F_{NH_3} 99-102 tt). The ammonia used for ammonia absorption comes from the ammonia distillation tower, and CO_2 and water vapor are contained in addition to the ammonia. In addition, the air (called filter air) drawn by the filter and the tail gas of the carbonation tower contain a certain amount of ammonia, which should be recycled and enter into the brine.

(1) Basic principle of ammonia absorption process

① Ammonia absorption reaction and equilibrium partial pressure of gas above ammoniacal brine The refined brine and the gas from ammonia distillation are mainly reacted as follows:



In addition, the gas is also reacted with a trace amount of residual Ca^{2+} and Mg^{2+} in the brine to produce a small amount of precipitates.

Ammonia absorption by brine is an absorption process accompanied by a chemical reaction. Since the amount of NH_3 and CO_2 gradually increases in the liquid phase, they are subjected to a chemical combination to produce ammonium carbonate, such that the partial pressure of ammonia is lower than the equilibrium partial pressure of ammonia of ammonia water with the same concentration. The more CO_2 in the solution, the lower equilibrium partial pressure of ammonia above the solution. Below $65^\circ C$, the temperature has little effect on the increase of a partial pressure of CO_2 . Especially when the ammonia concentration is high, the temperature has less effect on the partial pressure of CO_2 , but the temperature has a great effect on the partial pressures of water vapor and ammonia. As the temperature increases, the partial pressure of NH_3 increases significantly. When the temperature is relatively high, the content of CO_2 in the solution increases, which will enable the partial pressure of ammonia to decrease quickly, but the partial pressure of water vapor does not decrease much.

The above rules are very important for the processes of ammonia absorption, carbonation, and ammonia distillation in the production by the ammonia soda process. Someone has studied and measured the equilibrium partial pressure above the solution containing 85.5 tt NaCl and dissolved with different amounts of NH_3 and CO_2 . The results are shown in Figure 7-6.

① F_{NH_3} represents free ammonia.

② Interaction of solubility of raw salt and ammonia

The solubility of NaCl in water does not change much with the temperature, but the ammonia absorption in the saturated brine will slightly reduce the solubility of NaCl. The solubility of the ammonia in water is very large, but it is also reduced in the brine, that is, the equilibrium partial pressure of ammonia above the ammoniacal brine is larger than that above pure ammonia water. The effect of the temperature on the solubility of ammonia is the same as that of general gases, that is, high temperature leads to low solubility. In the process of ammonia absorption by brine, since CO₂ exists in a gas phase, the CO₂ can be dissolved in a liquid phase to produce (NH₄)₂CO₃, such that the solubility of the ammonia can be improved.

In the production of soda ash, ammonia absorption by second brine only requires free ammonia to reach 99-102 tt. This concentration is still far from the saturated concentration of ammonia at a room temperature. In theory, it seems to be better to absorb more ammonia. Although this is beneficial to the carbonation reaction, the solubility of NaCl in the liquid phase will decrease with the increase of the concentration of ammonia, which will cause adverse consequences on the availability and yield of sodium in the production of soda ash. Therefore, the relative concentrations of ammonia and salt in the ammoniacal brine must be both taken into account. According to the theoretical reaction, the value of F_{NH_3}/T_{Cl^-} should be 1. However, in consideration of the escape loss of ammonia, etc., the value is generally taken as 1.08-1.12 and according to experience, generally $F_{NH_3} = 99-102$ tt and $T_{Cl^-} = 89-94$ tt.

③ Thermal effect of ammonia absorption process

In the process of ammonia absorption, a lot of heat is released, including the heat of dissolution of NH₃ and CO₂, the heat of reaction of mutual neutralization, and the heat of condensation of water vapor contained in the gas from ammonia distillation. Under normal production conditions, about 2.16×10^6 kJ of heat is released per 1 t of soda ash produced. If this heat is not drawn out of the system, it will be enough to raise the temperature of the solution up to about 120°C, completely disabling the ammonia absorption tower. Therefore, cooling is the key to the ammonia absorption process.

④ Volume change in ammonia absorption process

After absorbing the ammonia, the brine has decreased relative density and increased volume. Besides, since the water vapor brought by the gas is condensed to dilute the saturated brine, the volume is more increased. In general, after the ammonia absorption, the volume increases by about 13.5%.

⑤ Essence of ammonia absorption process

Since the ratio of NH₃ and CO₂ molecules in the gas from ammonia distillation is about 4:1 to 5:1, the ammonia absorption by brine is essentially the process of absorbing NH₃ and CO₂ gases by the liquid phase at the same time. The absorption includes physical absorption and chemical absorption, wherein the chemical absorption is the combination of a part of NH₃ and CO₂ in the liquid phase. Besides, the rate of the chemical absorption is directly proportional to the concentration of free ammonia. The data is searched according to the production in recent years. It is found that the concentrations of CO₂ and NH₃ in the liquid phase at different heights along the tower are about a constant, such that the absorption of the CO₂ and NH₃ by the brine is

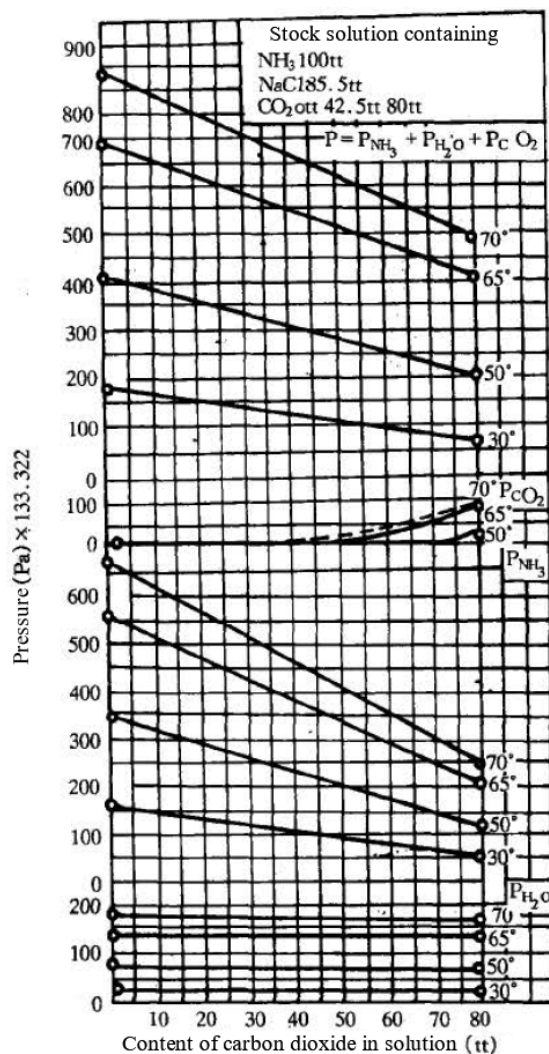


Figure 7-6 Partial pressures of NH₃, CO₂ and H₂O above ammoniacal brine

Notes: 1 tt = $\frac{1}{20}$ mol/L

proportional.

(2) Main device and process of ammonia absorption by brine

The main device of ammonia absorption is the ammonia absorption tower shown in Figure 7-7.

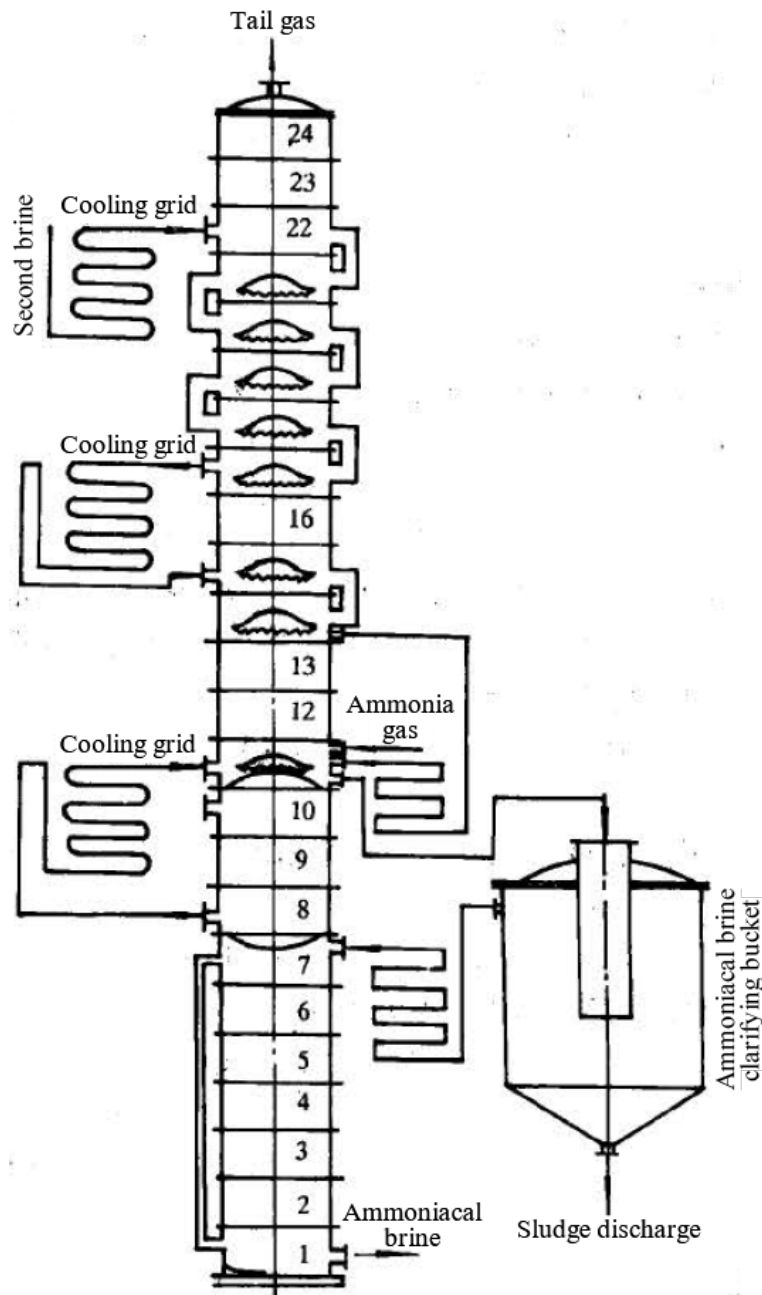


Figure 7-7 Structure of ammonia absorption tower and process

The ammonia absorption tower is a multi-section cast iron single bubble-cap tower. The process is also centered on the ammonia absorption tower. Refined brine is pumped into the top of the tower and gradually flows down from the top of the tower by its own weight. A single cap is installed in each circle to facilitate absorption. Since this absorption process is exothermic, in order to ensure good absorption, the brine is drawn out twice at upper and middle parts of the tower to a cooling grid (or a plate heat exchanger) for cooling, and then return to the next circle to continue to absorb ammonia. After the second cooling, the brine enters the ammonia gas inlet circle where the ammonia concentration is the highest and the heat release is the strongest. In order to ensure a good ammonia absorption effect and a certain concentration requirement, the brine is circulated for cooling and absorption, and a part of ammoniacal brine can be drawn out at any time. After sludge discharge by a clarifying bucket, the ammoniacal brine is cooled and sent into an ammoniacal brine tank (located at the lower 7th circle of the bottom of the tower). In countercurrent contact of gas and liquid, the ammonia content of the brine increases from the top to the bottom and the concentration of ammonia gas decreases from the bottom to the top. The trace ammonia contained in the tail gas from the tower is sent to an ammonia purification tower to be absorbed by water, and the obtained dilute ammonia water can be sent

to be dissolved into a salt.

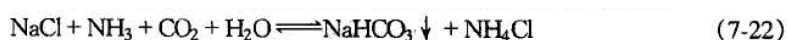
In order to save power, when the brine is drawn out to be cooled, it is necessary to ensure that the liquid has enough static head, such that it can overcome the resistance of the pipeline and return to the tower. To this end, it is necessary to carefully determine positions of inlets and outlets in the tower body, and add an empty circle if necessary.

Since the absorbed ammonia comes from the ammonia distillation tower, in order to reduce the leakage of the ammonia absorption system due to the unfirmness of the unit, speed up the distillation of CO_2 and NH_3 in the ammonia distillation tower, improve the production capacity of the ammonia distillation tower, and save the amount of water vapor, the ammonia absorption operation is performed under partial vacuum.

Although more than 99% of calcium and magnesium impurities have been removed from the refined brine, it is inevitable that a small amount of impurities will enter the ammonia absorption tower to form carbonate and a double salt precipitate. In order to ensure the quality of the ammoniacal brine, the clarifying bucket is provided for clarification again. The precipitation contained in the ammoniacal brine sent to carbonation should not exceed 0.1 g/L.

7.2.5 Carbonation of ammoniacal brine

Carbonation of ammoniacal brine is an important process in the production of soda ash by an ammonia soda process and simultaneously has unit processes such as absorption, crystallization, and heat transfer. These unit processes are interrelated and restrict each other. The basic reaction of the carbonation can be summarized by the following equations:



The purpose of the carbonation is to obtain NaHCO_3 crystals with high yield and good quality so as to be filtered and calcined to obtain a final product. The high yield of the crystals indicates that the utilization rate of NaCl and NH_3 is high, and therefore the product cost is reduced. The crystals have good quality, that is, the particles are large and uniform, and easy to separate from mother liquor, thus the amount of washing water can be correspondingly reduced, so as to obtain a final product of soda ash with relatively high purity and reduce the load of ammonia distillation.

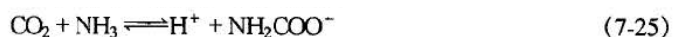
1. Reaction mechanism of CO_2 absorption by ammoniacal brine

Many researchers believe that the reaction mechanism can be divided into three steps: (1) production of ammonium carbamate; (2) hydrolysis of ammonium carbamate; and (3) precipitation of sodium bicarbonate crystals.

(1) Production of ammonium carbamate Experimental studies have confirmed that when CO_2 is introduced into concentrated ammoniacal brine, ammonium carbamate always appears initially.



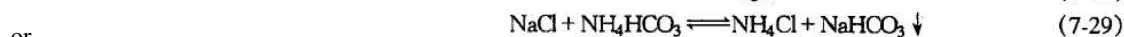
The possibility of this trimolecular reaction is very small, such that the reaction should be regarded as the following two reactions



(2) Hydrolysis of ammonium carbamate The produced ammonium carbamate above is further hydrolyzed and the reaction is:



(3) Precipitation of NaHCO_3 crystals by double decomposition. The step is the final purpose of the carbonation. When the carbonation degree reaches a certain value and the concentration of HCO_3^- in the solution is quite high, the product of the concentrations of HCO_3^- and Na^+ exceeds the solubility product of NaHCO_3 at this temperature, a precipitate is produced, and the double decomposition is completed:



The ammonia concentration in carbonated liquid is always relatively high and many times larger than the concentration of OH^- , such that most of the absorbed CO_2 is consumed in the reaction to produce ammonium carbamate, which has been confirmed by experiments.

The reaction of precipitating NaHCO_3 will affect the balance of a series of complex ionic reactions. The most important is to shift the hydrolysis reaction of ammonium carbamate to right, thereby accumulating dissolved ammonia in the solution, which has a significant impact on the absorption process.

2. Process conditions

(1) Carbonation degree and its effect on utilization rate of sodium

$$\text{Carbonation degree } R = \frac{\text{Mole number of total } \text{CO}_2}{\text{Mole number of total } \text{NH}_3} \times 100\% \quad (7-30)$$

Since it is NH_4HCO_3 rather than NH_3 that directly affects the equilibrium yield of NH_4HCO_3 , the carbonation degree indicates the degree of total ammonia converted into NH_4HCO_3 . Therefore, in the case of appropriate composition of ammoniacal brine, the larger R , the more complete conversion of the total ammonia into NH_4HCO_3 , and the higher utilization rate U_{Na} of NaCl . Therefore, in industrial production, the carbonation degree of the solution should be increased as much as possible to improve the utilization rate of sodium. However, due to various limitations of conditions, the carbonation degree in the production can generally only reach 180%-190%.

(2) Composition of ammoniacal brine

In order to obtain the highest utilization rate of sodium, the ratio of ammonia to salt in the ammoniacal brine must be ensured. However, in the actual production process, in addition to the insufficient carbonation degree R , the influence of ammonia brought out by the tail gas and NH_4HCO_3 eutectoid in sodium bicarbonate must also be considered.

① Ammonia brought out by tail gas and insufficient carbonation degree The most appropriate composition of ammoniacal brine is obtained based on the premise that the carbonation degree $R = 200\%$ of crystal mush taken out from the carbonation tower and the tail gas at the top of the tower does not bring out ammonia. However, in the actual production, the carbonation degree is usually less than 200% and the percentage of ammonia brought out by the tail gas accounts for about 6%-12% of the total ammonia. Therefore, the ratio of NH_3/NaCl in the ammoniacal brine must be increased to make up for the lack of ammonia.

② Influence of NH_4HCO_3 eutectoid in sodium bicarbonate on ratio of ammonia to salt The ratio of ammonia to salt in the ammoniacal brine should be higher than the theoretically calculated ratio of ammonia to salt, which is not only because the tail gas at the top of the tower brings out ammonia, but also because a part of NH_4HCO_3 is brought out in a form of eutectic in the NaHCO_3 precipitate.

③ Optimum ammonia absorption amount As can be seen from the above discussion, properly increasing the ratio of ammonia to salt can improve the utilization rate of sodium, but in the process of ammonia absorption, every 1 mol of ammonia absorbed will bring in about 0.4 mol of water vapor. Therefore, the more ammonia is absorbed, the lower the concentration of NaCl in the ammoniacal brine, and the more deviated from the most appropriate composition of the ammoniacal brine.

The most appropriate ratio of ammonia to salt in the ammoniacal brine can be calculated using a solubility diagram of $\text{NH}_3\text{-NaCl-H}_2\text{O}$ and is generally 1.12-1.14.

(3) Influencing factors of carbonation absorption rate

In the carbonation process, increasing the pressure, lowering the temperature, and keeping a stage of low carbonation degree are all beneficial to increase the absorption rate.

(4) Crystallization process of sodium bicarbonate and influencing factors

Since the production conditions are different, the sodium bicarbonate crystal produced in the carbonation tower also has different quality. The crystal quality includes factors such as particle size and shape. The non-whisker-like crystals having large, uniform and complete grains, and similar three-dimensional lengths are considered to have good quality. When the crystal quality is good, filtration and washing are facilitated, the sodium bicarbonate contains less water, the yield is high, the content of salt is less after calcination, and the quality of soda ash can be improved. Therefore, crystallization is important to the product quality in the whole production of soda ash.

The solubility of NaHCO_3 in water decreases with the decrease of the temperature, but the NaHCO_3 can easily form a supersaturated solution. Since the precipitation of NaHCO_3 crystals in the supersaturated solution is similar to the general crystallization process, that is, the greater the degree of supersaturation, the faster the crystallization speed. However, the crystals have a small particle size and poor quality, which is unfavorable for filtration and calcination.

According to the crystallization kinetics, under the same supersaturation condition, a growth rate of crystal grains is greater than a generation rate of crystal nuclei at a high temperature. Therefore, maintaining a higher temperature (about 60°C) in the

initial stage of the crystallization will not produce too many small crystals. Experiments have shown that if 50% of NaHCO_3 is crystallized at a suitable temperature, in a second half stage of the crystallization, due to the existing good foundation, the overall quality is guaranteed. The higher temperature in the middle of the tower is maintained by the heat of reaction. The cooling process of the temperature in the middle decreased to about 25°C of the temperature of discharge from the tower should be performed gradually. Because although there is a good foundation at this time, too fast cooling will still cause excessive supersaturation, which may produce new small crystals.

The good operation of the carbonation tower should be to precipitate large and complete sodium bicarbonate crystals to meet the requirement of the next step of separation from mother liquor. Otherwise, the product quality will be affected and the load of the ammonia distillation process is also increased.

The quality of the crystals can be expressed by settling time and settling rate. The settling time is determined by taking 100 ml of the crystal mush under the tower with a measuring cylinder and measuring the time required from standing to separation of liquid and solid phases. Generally, 150-200 s is required to be qualified. The settling rate is the percentage of the volume of the solid phase layer to the total volume after layering and generally required to be 40%-50%.

A large amount of heat is released during the carbonation process, which will increase the temperature of the liquid entering the tower. But when the temperature is high, the solubility of the sodium bicarbonate is large. Therefore, the temperature should be gradually lowered after the crystallization, and thus the reaction tends to be completed and crystals are precipitated as many as possible. When the precipitation continues, the crystals can grow up and the quality is ensured. At this time, special attention should be paid to controlling the cooling rate. A relatively high temperature (usually the temperature at the middle part) should be maintained for a period of time in order to produce sufficient crystal nuclei. If the cooling time is too short, the crystal nuclei are not yet formed, thereby increasing supersaturation and finally resulting in a large number of small crystals which are not grown up even when taken out and form “small crystal mush” (also called “floating soda”). However, if the cooling time is too long, the utilization rate of equipment will be reduced. The lower part of the tower should not be cooled too fast to avoid the production of small crystals. Generally, the residence time of the liquid in the tower is about 1.5-2 h and the discharge temperature is about 25°C .

In order to keep the supersaturation at a constant value and not increased too quickly, the speed of cooling should be slow at the beginning. However, the cooling can be slightly faster before the final discharge from the tower, since the carbonation degree is already high, the reaction speed is slowed down, and the large supersaturation is not easy to form. Appropriate acceleration of the cooling will not produce small crystals, but can improve the yield. To ensure crystal quality, the temperature distribution of each layer in the tower is required as shown in Figure 7-8. It can be seen from the figure that the maximum reaction temperature is about 65°C at about 2/3 of the tower height and then the temperature is gradually cooled to reach the discharge temperature of $22\text{-}28^\circ\text{C}$ or slightly higher.

3. Carbonation process and carbonation tower

(1) A typical process for carbonation is shown in Figure 7-9.

The ammoniacal brine is injected into a washing tower (also known as a pre-carbonation tower and a neutralization tower), the kiln gas is blown into the tower to dissolve the scale in the tower, initially increases the carbonation degree, and then is sent to the sodium bicarbonate making tower, and the kiln gas and furnace gas obtained by calcining sodium bicarbonate are boosted by a (reciprocating or centrifugal) compressor and then sent to the tower. The crystal mush discharged from the tower is self-pressed to a sodium bicarbonate solution tank by the liquid level and sent to the filtration process. After a period of production by the sodium bicarbonate making tower, the scale in the tower is relatively thick and the heat transfer is poor, which is unfavorable for crystallization. At this time, the washing tower has been cleaned and can be used interchangeably, which is called “interchange of towers”. The tail gas of the two towers contains a small amount of ammonia and carbon dioxide. After gas-liquid separation, the tail gas is sent to a brine workshop for refining the brine. In the actual production process, several towers consist of a group with one tower for washing and the other towers for producing soda ash.

2. Structure and performance of carbonation tower

The carbonation tower is one of the main devices for producing soda ash by an ammonia soda process. It is assembled

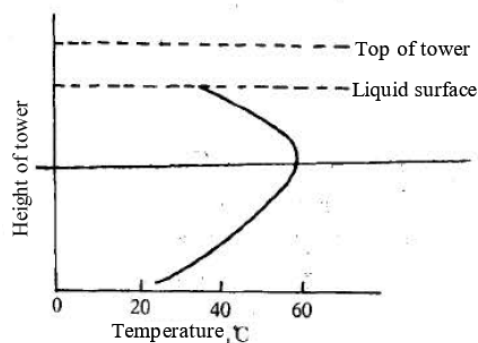


Figure 7-8 Temperature distribution of carbonation tower at different heights

from many cast iron tower circles and its structure can be roughly divided into upper and lower parts: The upper part is a CO₂ absorption tower section. A hat-shaped plate and a slightly downwardly inclined liquid leakage plate are arranged between each circle. Teeth are arranged for dispersing air bubbles on the edges of the plates and the hats to increase the contact area of gas and liquid to promote absorption. About ten cooling water tanks are arranged in the lower part of the tower to cool the carbonated liquid to precipitate crystals. No cap is arranged in the middle of the water tanks. The bottom of the carbonation tower is provided with a crystal mush outlet and an inlet of concentrated CO₂ gas (lower-section gas) and the middle part of the cooling section is provided with an inlet of dilute CO₂ gas (middle-section gas) (this is the two-section gas intake). The top of the tower is provided with a liquid inlet and a tail gas outlet, and the tower is about 22-25 m high to maintain a certain liquid column and residence time. Since too high static pressure will cause a waste of compressor power, it is also unnecessary if the liquid column is too high. The carbonation degree of the crystal mush discharged from the tower will not increase much.

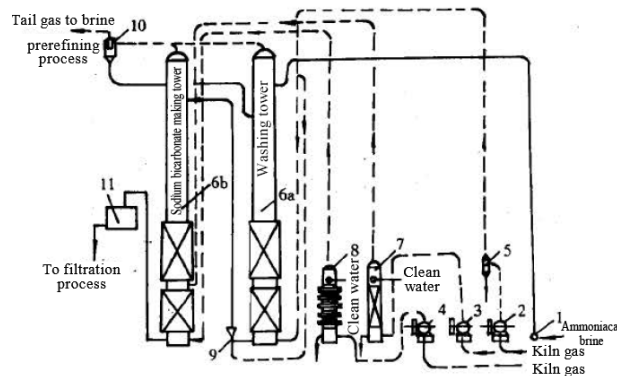


FIG 7-9 Schematic flow diagram of carbonation

1-ammoniacal brine pump; 2-washing gas compressor; 3-middle-section gas compressor; 4-lower-section gas compressor; 5-separator; 6a, 6b-carbonation tower; 7-middle-section gas cooling tower; 8-lower-section gas cooling tower; 9-air-lift brine transporter; 10-tail gas separator; and 11-sodium bicarbonate solution tank

The diameter of the carbonation tower is generally 1.98-3.2 m. There is a trend of large-scale development at present.

The front and rear pattern plates of the cooling water tanks are provided with separation plates, such that the cooling water can pass through in a “Z-shaped” manner or a “grid-shaped” manner to utilize heat transfer. The cooling water tanks are mostly made of cast iron and the initial heat transfer coefficient is 186-233 W/m².K. The heat transfer coefficient is dropped to about 105-140 W/m².K in the later stage. According to experience, daily production of per ton of soda ash requires a cooling area of 6-8 m².

Each soda ash factory in our country still mainly uses traditional equipment whose main performances are shown in Table 7-4.

Table 7-4 Structure and main process performance of carbonation tower of different sizes

Tower diameter (mm)	1,200	1,600	1,980	2,500	3,200
Tower height (mm)	22,542	18,200	25,069	25,117	26,650
Cap Upper section	16	16	21	21	29
Number Lower section	0	0	11	10	
Height of tower circle (mm)	600	450	375, 506	420	540, 800
Opening percentage of separation plate (%)	11.3	9.55	9.0	8.4	9.8
Opening percentage of upper cover (%)	33.7	23.4	33.5	31.5	-
Number of water tanks	10	10	11	9	12
Cooling area (m ²)	128	200	Inside 459 Outside 533	Inside 737 Outside 912	1,921
Operating pressure (Mpa)	1.3	0.7	0.4	0.4	0.3
Production capacity (t/d)	21	35.6	74	122	220-240
Air speed of empty tower (m/s)	0.0355	0.038	-	-	-
Production intensity (t/m ³ .d)	0.843	0.554	0.716	0.98-1.15	1.22-1.33

Since the water tank hat-type carbonation tower has disadvantages of scaling of cooling surface, short production cycle, complex structure, large construction investment, etc., the natural circulation external cooling-type carbonation tower developed in our country has been tested on an industrial scale in 1985. The tower is shown in Figure 7-11.

The diameter of the upper section is 2.5 m, the diameter of the lower section is 2.8 m, and the height is 26.5 m. Two external coolers have a diameter of 1.3 m and a height of 7.4 m. The upper part of the tower is a sieve plate and a bubble cap, the middle and lower parts are provided with multiple central circulation pipes, a suspension in the tower is discharged through the circulation outlet j, and after cooling, the liquid returns to the tower through the circulation inlet m and is taken out from the sodium bicarbonate outlet a.

3. Operation of carbonation tower

In order to ensure that a sodium bicarbonate crystal mush is continuously sent to the filtration process, several carbonation towers are connected into a group to operate. Usually four towers are used as a group, wherein three towers are used for producing sodium bicarbonate; and one tower is a pre-carbonation tower.

In the past, one-section gas intake was used in the carbonation tower. The intake gas is a mixture of kiln gas and furnace gas (CO_2 gas from combustion) and the concentration is very difficult to exceed 60%. Two-section gas intake is used later, that is, the furnace gas with a high concentration is fed from the bottom of the tower, and the kiln gas (with a concentration about 36%-40%) is fed into the middle part of the cooling section, which is more in line with a countercurrent principle. Therefore, absorption is strengthened, carbonation degree is improved, and the utilization rate of sodium is improved. The washing tower is mainly used for washing the scales and required to promote the dissolution and increase the temperature appropriately. Therefore, the kiln gas is introduced from the bottom of the tower and the cooling water and the middle-section gas inlet are closed. In the operation of the carbonation tower, it is generally necessary to master the amount and concentration of the lower-section gas. Practice has pointed out that a part of the kiln gas is sent to the lower section, such that the concentration of the lower-section gas is reduced from 90% to 82%-84%, the carbonation cycle is increased, and a conversion rate can be high and stable. This is mainly due to the fact that the increase of the volume of the lower-section gas improves efficiency. However, if the volume of the lower-section gas is too large, the reaction zone will move down, which will increase the scaling of cooling water pipes and shorten the carbonation cycle in turn. Experience has proved that if the volume of the lower-section gas is appropriately increased and the concentration of CO_2 is maintained at about 84%, the yield will not decrease, but the conversion rate will increase.

The appropriate control conditions of the carbonation tower are as follows:

(1) The height of the liquid level of the carbonation tower should be controlled within 0.8-1.5 m from the top of the tower. If the liquid level is too high, a phenomenon of liquid in the tail gas will be frequent and an air outlet header pipe is blocked. If the liquid level is too low, the output gas will contain a large amount of ammonia and CO_2 , which will increase the loss and reduce the production capacity of the tower.

(2) It is better to strictly control the temperature in the middle part of the tower to be higher, and a warm area distributed in a height direction should be wider to ensure the crystal quality. This is because maintaining a high temperature in the middle part not only has a high conversion rate, but also can enable NaHCO_3 crystal grains to be large and uniform. The area with the

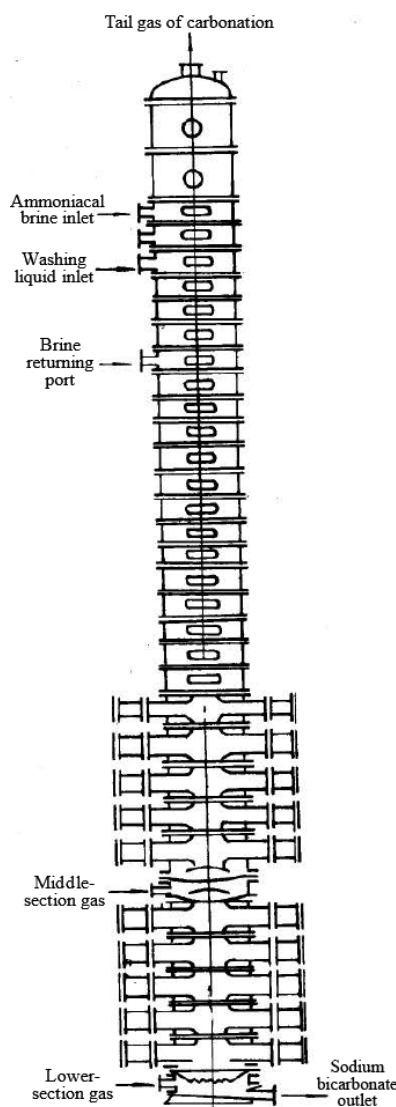


Figure 7-10 Carbonation tower

highest temperature in the middle part is about 3/5 of the tower height.

(3) The gas intake amount of the carbonation tower corresponds to the sodium bicarbonate discharge speed. Otherwise, if the sodium bicarbonate discharge speed is too fast and the gas intake amount is insufficient, the reaction zone will move down, resulting in production of small crystals and decrease of yield. On the contrary, the reaction zone will move up and the loss of NH_3 and CO_2 at the top of the tower will be too large.

(4) The sodium bicarbonate discharge temperature should be kept appropriate. If the sodium bicarbonate discharge temperature is low, more NaHCO_3 will be precipitated, the conversion rate is high, and the yield is increased. However, if the temperature is too low, too much cooling water will be consumed, the tower is blocked and the operation cycle is shortened. The sodium bicarbonate discharge temperature is mainly achieved by adjusting the volume of cooling water. But it must be noted that the adjustment should not be too fast, so as to avoid sudden cooling to produce small crystals and block the tower.

(5) The tower should be replaced according to the specified time and return to normal within 2 h. In the operation of the carbonation tower, severe fluctuations in temperatures, flow rate, etc. should be avoided as much as possible. During normal operation, the composition of gas and liquid phases, temperatures, etc. are different on cross sections of different tower heights, but are required to be stable on the cross section.

7.2.6 Filtration of sodium bicarbonate

In the production of soda ash, the filtration process is used to separate NaHCO_3 crystals in a suspension from the carbonation tower. The obtained crystals are sent to a calcination section, and mother liquor together with washing water (called filtrate) is sent to the ammonia distillation section to recover ammonia.

The main task of the filtration section of soda ash is to enable the NaHCO_3 sent into the calcination section to form a continuous material flow. The process indicators are: water content in the wet NaHCO_3 is 13%-18%, NaCl content is less than 0.4%, and total ammonia content is less than .8%. Therefore, a filter cake must be washed during the filtration to wash away the residual mother liquor in the sodium bicarbonate to minimize the NaCl contained in the soda ash. Soft water should be used as the washing water so as to prevent Ca^{2+} and Mg^{2+} contained in the water from forming a precipitate to block a filter cloth.

(I) Filter

The main equipment in the filtration section is a continuous rotary drum vacuum filter.

Vacuum filtration is as follows: a filter drum of the filter is pumped into negative pressure by a vacuum machine, a pressure difference is formed on both sides of the filter cloth, such that the mother liquor is pumped away through the filter cloth, and the sodium bicarbonate is trapped on the surface of the filter cloth, then removed by a scraper, and sent to the calcination process to be calcined into soda ash. The continuous rotary drum vacuum filter has advantages of continuous operation, large production capacity, and high degree of automation, and thus is suitable for large-scale production. However, the filtered sodium bicarbonate has relatively high water content, the lowest water content is about 15%, and sometimes the water content is as high as 20% or more.

The vacuum filter is as shown in Figure 7-12.

According to the process, the rotary drum of the filter can be conditionally divided into the following zones:

filtration zone: under vacuum, the mother liquor is sucked into the rotary drum, but the NaHCO_3 crystals remain on the

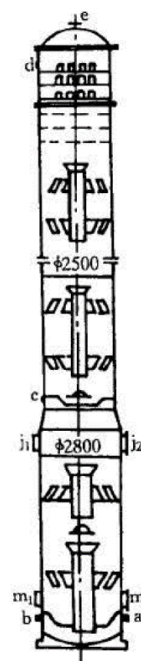


Figure 7-11 Natural circulation external cooling-type carbonation tower

a-sodium bicarbonate outlet; b-lower-section gas inlet; c-middle-section gas inlet; d-inlet of ammonia mother liquor II; e-tail gas outlet; j_{1,2}-external circulation outlet; and m_{1,2}-external circulation inlet

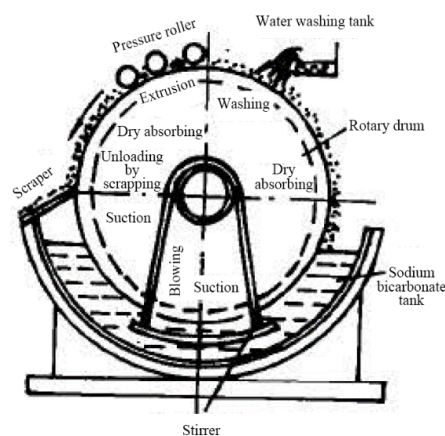


Figure 7-12 Schematic diagram of function of rotary drum of vacuum filter during process of one rotation

surface of the filter cloth to form a filter cake;

pre-drying zone: at this time, the surface of the rotary drum is above the suspension, and the mother liquor is sucked from the filter cake into the rotary drum;

filter cake washing zone: washing water is supplied to the surface of the rotary drum, passes through the filter cake, enters into the rotary drum, and drives out the mother liquor from the intercrystalline space of the filter cake at the same time;

primary drying zone: air is supplied into the zone, passes through a NaHCO_3 filter cake layer, discharges the washing water from the intercrystalline space of the filter cake, and thus reduces the water content of the filter cake;

closed zone: the NaHCO_3 filter cake is scraped off from the surface of the rotary drum using a scraper and the air is prevented from being sucked into the rotary drum at a gap between the scraper and a mother liquor suction zone;

mother liquor suction zone: the so-called “wet” purging of the filter cloth is performed before blowing compressed air, which is a necessary operation to prolong the service life of the filter cloth;

Air blowing zone: the compressed air is fed into a small chamber to restore the filter cloth in an opposite direction to movement of a gas-liquid mixture (entering the rotary drum in vacuum), first passes through the filter cloth, and drives out the mother liquor that has entered the mother liquor suction zone from the small chamber; after passing through the filter cloth, the mother liquor drives out the NaHCO_3 crystals from the pores of the filter cloth and also dissolves the crystals, thereby speeding up the regeneration process of the filter cloth; and Then the filter cloth is purged with the compressed air; and

transition zone: the zone is used to prevent the compressed air fed into the purge from entering the vacuum chamber.

When the rotary drum rotates one circle to complete the entire process cycle, each chamber of the rotary drum passes through each zone.

The production capacity of the vacuum filter used in domestic soda ash factories is mostly 300-350 t soda ash/d and the daily production capacity of the large-scale vacuum filter is 500-600 t.

(II) Process and control requirements of vacuum filtration

A brief process of vacuum filtration is shown in Figure 7-13:

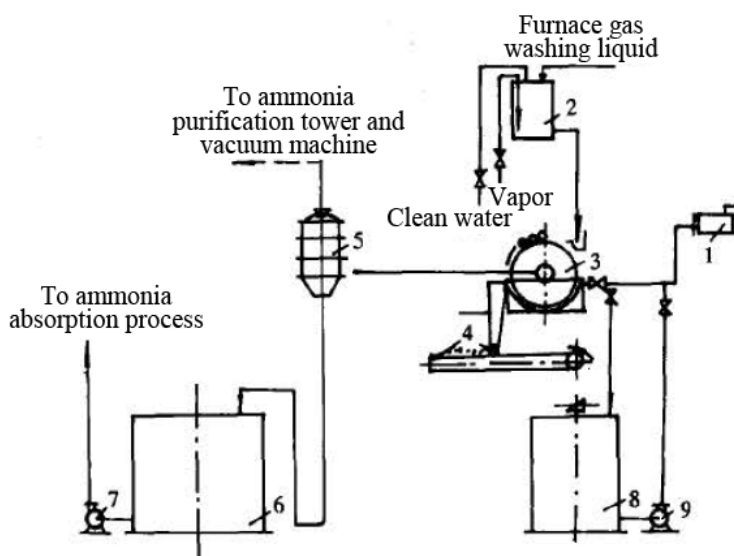


Figure 7-13 Flow diagram of filtration of sodium bicarbonate

1-sodium bicarbonate solution discharge tank; 2-washing water tank; 3-filter; 4-belt conveyor; 5-separator; 6-mother liquor I bucket; 7-mother liquor I pump; 8-sodium bicarbonate solution bucket; and 9-sodium bicarbonate solution pump

The sodium bicarbonate crystal mush from the bottom of the carbonation tower flows into a sodium bicarbonate tank of the vacuum filter through the sodium bicarbonate solution tank. There is a stirrer in the tank to prevent the sodium bicarbonate from depositing in the sodium bicarbonate tank. During normal operation, about two-fifths of the lower part of the filter drum is immersed in the sodium bicarbonate tank. Due to the action of the vacuum system, the liquid is drawn into the rotary drum through the pores of the filter cloth, but the sodium bicarbonate crystals are trapped on the filter cloth. With the rotation of the rotary drum, the sodium bicarbonate on the filter cloth is washed and sucked dry, then transferred to the scraper to be scraped off, and sent to the calcination process by the sodium bicarbonate belt conveyor. After the sodium bicarbonate is scraped off by the scraper, 3-4 mm thick sodium bicarbonate still remains on the filter cloth and needs to be blown off with compressed air to

restore the filter cloth for continued use.

When the liquid is sucked into the rotary drum, it absorbs a part of the air at the same time, and this part of the filtrate and the gas are separated by the gas-liquid separator. In addition to air, the gas also contains a small amount of NH_3 and CO_2 which need to be discharged from the vacuum machine after passing through the ammonia purification tower. The mother liquor is sent to the ammonia distillation process.

After the vacuum filter is used for a period of time, it needs to be stopped and washed with warm water due to the blockage of the filter cloth.

The operation of the vacuum filter is mainly by adjusting the vacuum degree. The vacuum degree (26.7-33.3 kPa) determines the production capacity of the filter, the water content in the sodium bicarbonate, and the quality of the final product. The second is the washing of the filter cake. If the temperature of the washing water is too high, the NaHCO_3 dissolution loss is large; and if the temperature of the washing water is too low, the filter cake is not easy to clean. Therefore, the temperature of the washing water usually should be close to the temperature of the crystal mush. Excessive amount of the washing water will increase the volume of the mother liquor, which increases the load of ammonia distillation in addition to increasing the loss of NaHCO_3 ; and If the amount of the washing water is too small, the salt cannot be washed completely. The amount of the washing water is determined by the quality of the sodium bicarbonate crystals to maintain the maximum amount of NaCl in the obtained final product of soda ash to be less than or equal to 1%.

If the filter uses a metal filter screen instead of coarse cotton cloth or man-made fibers, the operation cycle is longer and the utilization rate of the equipment can be improved.

7.2.7 Calcination of sodium bicarbonate

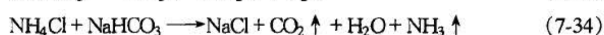
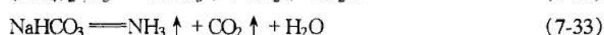
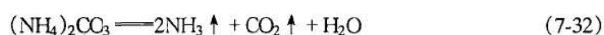
The sodium bicarbonate is calcined and decomposed to obtain a soda ash product. The requirement for calcination in production is that the final product contains less salt and does not contain undecomposed NaHCO_3 ; the produced furnace gas contains a high concentration of CO_2 and the loss is less; and less fuel is consumed.

(I) Principle and equipment of sodium bicarbonate calcination

Sodium bicarbonate is an unstable compound, and can be decomposed at a room temperature and rapidly decomposed by increasing the temperature.



Through thermodynamic calculation, it can be known that when the temperature is 100-101°C, the decomposition pressure has reached 0.1 MPa, that is, NaHCO_3 can be completely decomposed. But in practice, the reaction is very slow at this temperature. The higher temperature leads to the faster reaction. Under the condition of 190°C, NaHCO_3 can be completely decomposed within half an hour. Therefore, in fact, the soda ash discharging temperature of the calcination is mostly controlled at 165-190°C. In the calcination process, in addition to the above reaction and free water in the sodium bicarbonate being heated to water vapor, the following side reactions also occur:



These side reactions not only consume heat, but also increase the amount of circulating ammonia in the system, thereby increasing the ammonia consumption. At the same time, since the last reaction is a double decomposition reaction, NaCl is left in the product, which affects the quality of the product. It can be seen that in the filtration process, sodium bicarbonate washing is very important.

During the calcination process of the sodium bicarbonate, a very high concentration of CO_2 , the so-called “furnace gas”, can be obtained. At present, as for the production in our country, the CO_2 in the furnace gas can reach about 90%, while a calcination rate of sodium bicarbonate is about 51%.

The device for calcining sodium bicarbonate is called calcining furnace. At present, an internal heating-type steam calcining furnace is mainly used in the production. The steam calcining furnace is shown in Figure. 7-14. The furnace body is horizontally cylindrical. The furnace has the specification of $\phi 2.5$ m and the length of 27 m, and is provided with two rolling rings arranged 16 m apart. The weight of the furnace body and the material is transmitted to a supporting roller through the rolling rings. The supporting roller is in a form of a rolling bearing due to the heavy load. A rear end support is provided with a catch wheel to prevent the furnace body from axially moving, and a gear ring is arranged on the furnace body close to the supporting roller and the catch wheel to drive the cylinder body to rotate. The furnace body is internally provided with three layers of steam heating

pipes which are supported on the furnace by a pipe frame, and spiral heat-conducting fins are welded on the outsides of the pipes to increase the heat transfer surface. A gas chamber is located at the tail of the furnace. After a high-pressure steam is introduced, condensed water is still returned to the gas chamber from an original pipe, flows into a condensed water chamber of an outer ring, is sent to a flash vessel by a steam trap, a part of the steam is flashed out, and the condensed water returns to a boiler.

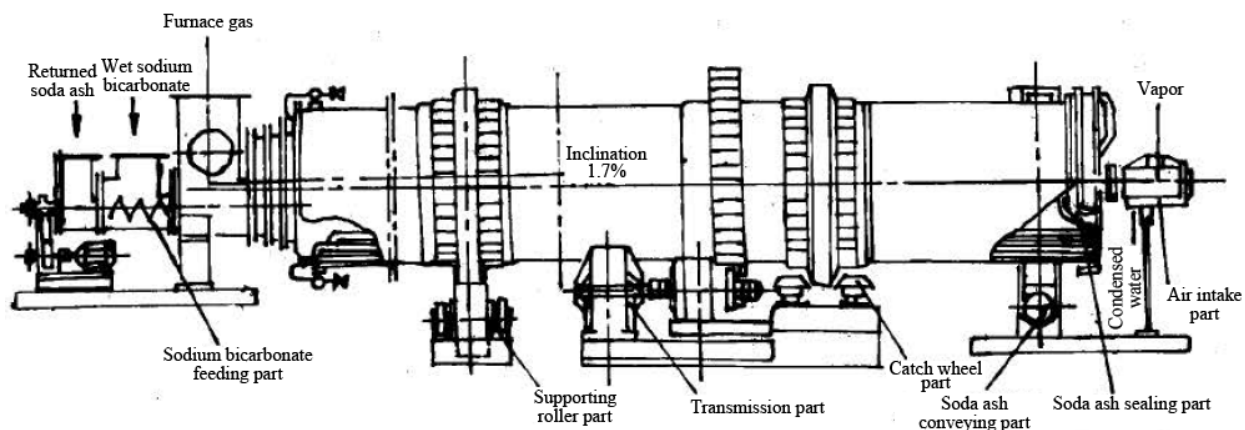


Figure 7-14 Steam calcining furnace

The head of the steam calcining furnace is provided with a sodium bicarbonate feeding screw conveyor and a furnace gas outlet, and the furnace layer is provided a soda ash discharging screw conveyor, a steam inlet, and a condensed water outlet.

The internal heating-type steam calcining furnace has advantages of large production capacity, less maintenance, good working conditions, high thermal efficiency, etc.

(II) Process and operation of sodium bicarbonate calcination

1. Process of sodium bicarbonate calcination

The process of sodium bicarbonate calcination using the internal heating-type steam calcining furnace is shown in Figure 7-15. The sodium bicarbonate is conveyed by a belt conveyor, enters a disk feeder to control the addition amount of the sodium bicarbonate, then is mixed with returned soda ash through the sodium bicarbonate feeding screw conveyor, and is mixed with dust from a furnace gas separator into the furnace. The mixture is indirectly heated and decomposed by a medium-pressure steam for about 20 min, a final product is discharged from the furnace by the soda ash outlet screw conveyor, conveyed by a series of conveying equipment, and then a part of the final product is sent back to the furnace body for returning soda ash and a part is sent to a cylinder sieve and a bin.

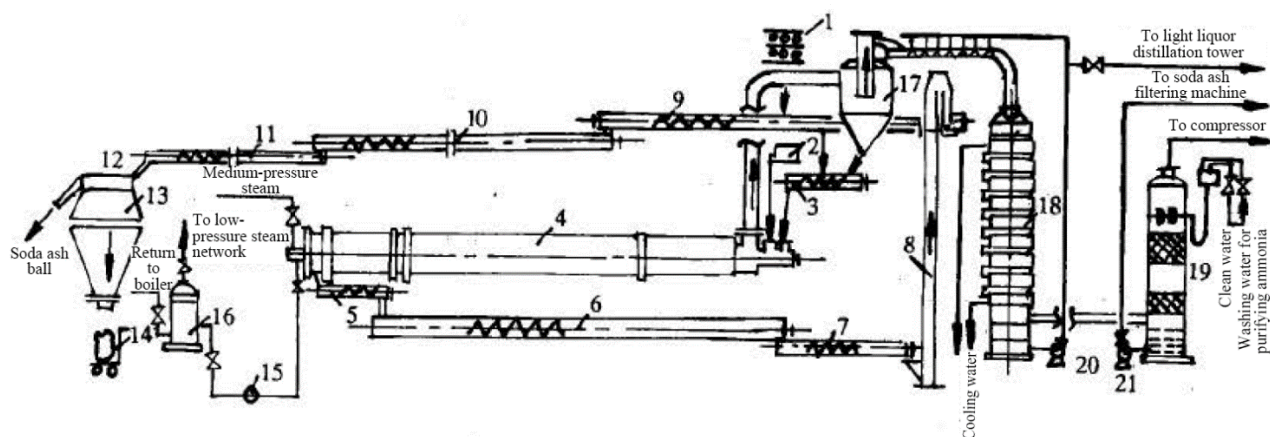


Figure 7-15 Process flow chart of steam calcining furnace

1-belt conveyor; 2-disk feeder; 3-returned soda ash screw conveyor; 4-calcining furnace; 5-soda ash discharging screw conveyor; 6-underground screw conveyor; 7-soda ash feeding screw conveyor; 8-bucket elevator; 9-distributing screw conveyor; 10-final product screw conveyor; 11-screw conveyor above sieve; 12-cylinder sieve; 13-soda ash bin; 14-weighing scale; 15-steam trap; 16-flash vessel; 17-separator; 18-condensing tower; 19-washing tower; 20-condensing pump; and 21-washing water pump;

The furnace gas generated in the calcination process is subjected to dust removal, cooling, and washing, the concentration of CO₂ is about 90%, and the furnace gas is pumped to the carbonation tower for use by a CO₂ compressor.

In recent years, Tianjin Soda Ash Plant has adopted three calcining furnaces with a diameter of 3.6 m, a length of 34 m, and a weight of 194 t in a 0.6 Mt soda ash extension project. The calcining furnaces are the biggest in the soda industry of our country at present.

2. Operation control points of steam rotary calcining furnace

(1) Soda ash discharge temperature The temperature is generally controlled at 150-190°C to completely decompose sodium bicarbonate. If it is lower than 150°C, the quality is unqualified. In order to avoid burning a packaging bag, according to material requirements of the packaging bag, the hot soda ash discharged from the furnace should be further cooled to about 50-100°C.

(2) Furnace gas temperature The furnace gas temperature should be kept at 108-115°C as far as possible. In order to make an air outlet pipe and a cyclone dust collector not sticky and not blocked, it is necessary to use steam to keep warm.

(3) Medium-pressure steam It is generally supplied by a power plant. The steam has a pressure of 2.9-3.3 MPa and a superheat temperature depending on a conveying distance, generally superheat for 25-50°C, so as to ensure that the steam is slightly overheat when entering the furnace and avoid condensation of steam in a header pipe.

(4) Soda ash returning amount In order to avoid scaling in the furnace due to relatively high water content of sodium bicarbonate in the production, a certain amount of calcined final product sodium carbonate (called returned soda ash) is mixed with the sodium bicarbonate to appropriately reduce the average moisture to 6%-8%.

(5) Amount of stored ash The amount of stored ash in the calcining furnace indicates length of reaction time of sodium bicarbonate in the calcining furnace. In order to ensure the complete decomposition of the sodium bicarbonate, it is necessary to ensure a certain amount of stored ash. The amount is related to the size of the calcining furnace. Currently, for a calcining furnace with a diameter of 2.5 m, the amount of stored ash should be kept at 20-25 t.

(III) Specifications of soda ash and manufacture of dense soda ash

The final product, soda ash, is obtained after the calcination, and is a white powder. Its composition should meet the specifications in Table 7-5.

Table 7-5 Specifications of soda ash product

Name of index	National standard (GB210-80)		
	First-grade product	Second-grade product	Third-grade product
Total amount of soda ash (calculated as Na ₂ CO ₃) (%) ≥	99.0	98.5	98.0
Chloride (calculated as NaCl) (%) ≤	0.80	1.0	1.2
Iron (calculated as Fe ₂ O ₃) (%) ≤	0.008	0.01	0.02
Water insoluble matter (%) ≤	0.10	0.15	0.20
Loss on calcination (%) ≤	0.5	0.5	0.7

The generally produced soda ash has a bulk density of 0.5-0.6 t/m³, which is called light soda ash or light ash. This soda ash occupies a large volume, is inconvenient for packaging and transportation, and is lost much due to scattering during use. Therefore, the soda ash is generally produced to a bulk density about 0.8-1.1 t/m³, which is called dense soda ash or dense ash.

The dense ash is mainly prepared by the following method:

1. Hydration method

The process of preparing dense soda ash by a hydration method is shown in Figure 7-16.

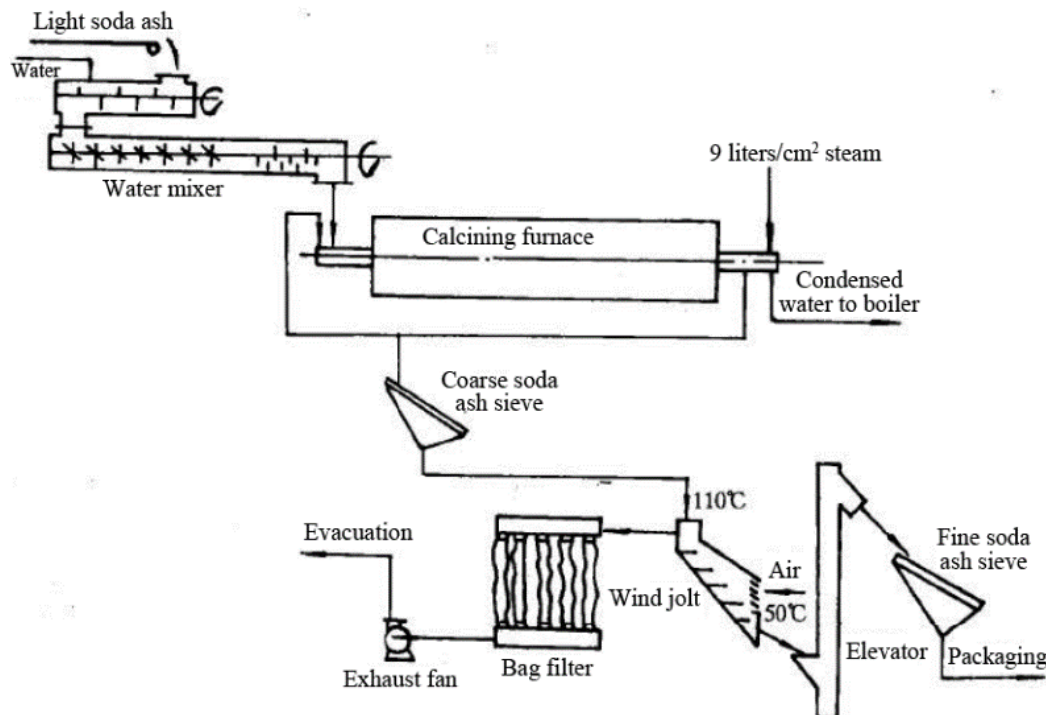
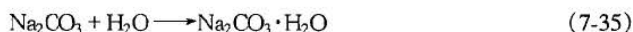


Figure 7-16 Process of preparing dense soda ash by hydration method

The light ash from the calcining furnace at a temperature of 150-170°C is sent into a water mixer by a screw conveyor, and at the same time, hot water is sprayed into the water mixer to be evenly mixed with the light ash. The following reactions occurs:



The water mixing is conducted at a temperature of 90-100°C for 20 min, wherein the water content in the mixture is 17%-20%. The obtained sodium carbonate monohydrate is indirectly heat exchanged with low-pressure steam (about 1 MPa) in a dense ash calcining furnace. The sodium carbonate monohydrate loses crystal water when heated to obtain the dense ash. A part of the dense ash is returned and a part of final product is sieved, cooled, and packaged.

Since the furnace gas produced in the furnace contains soda ash dust, dust removal and washing should be conducted before evacuation.

2. Mechanical extrusion method

The mechanical extrusion method is a new method for producing dense soda ash. The light ash from the calcination process is conveyed to a stock bin connected to a rolling mill by a scraper conveyor and fed to the rolling mill by a vertical and horizontal screw conveyor (a feeder). The light ash is crushed under a mechanical pressure of 230 t and the obtained particles are conveyed into a first vibrating sieve through a scraper conveyor and a bucket elevator for sieving. The particles larger than 2 mm are sent to a grinder to be ground, the particles of 0.3-2 mm are sent to a final product process, and the particles smaller than 0.2 mm are returned to the light ash section. The particles from the grinder pass through a secondary vibrating sieve, the particles larger than 2 mm are sent to the grinder again, and the particles of 0.3-2 mm are sent to the final product process. The particles smaller than 0.2 mm are returned to a light ash bin.

The dense ash from the first and secondary sieving machines is then graded by a sieving machine, and the particles of 0.3-2 mm and 0.2-1 mm are packaged separately. The process is shown in Figure 7-17.

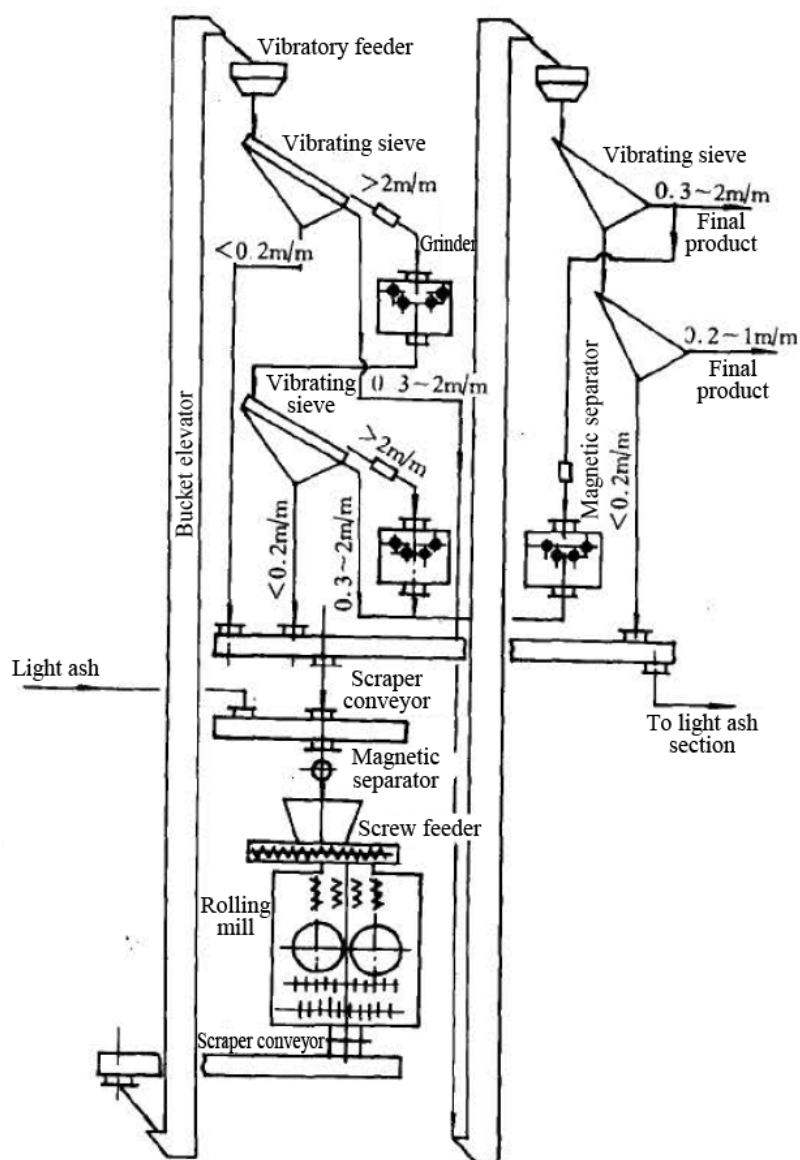


Figure 7-17 Process of preparing dense soda ash by mechanical extrusion method

3. Crystallization method

The crystallization method is as follows: the light ash sent from the calcination process is added into a crystallizer pre-stored with a NaCO_3 solution and an appropriate amount of a NaCO_3 solution is added while the light ash is added. The temperature within the crystallizer is kept at about 105°C . In this way, the light ash will be converted into $\text{NaCO}_3 \cdot \text{H}_2\text{O}$ crystals in the crystallizer. The reaction is the same as that of the hydration method.

In order to remove the heat of reaction and maintain the temperature of the crystallizer stable, a part of the solution must be withdrawn for circulating cooling. In the $\text{NaCO}_3 \cdot \text{H}_2\text{O}$ slurry in the crystallizer, the content of suspended solids is preferably below 50%. The obtained NaCO_3 slurry is filtered or centrifuged to obtain $\text{NaCO}_3 \cdot \text{H}_2\text{O}$ crystals which are then calcined in a dense ash calcination furnace to obtain dense ash. The process flow diagram is shown in Figure 7-18.

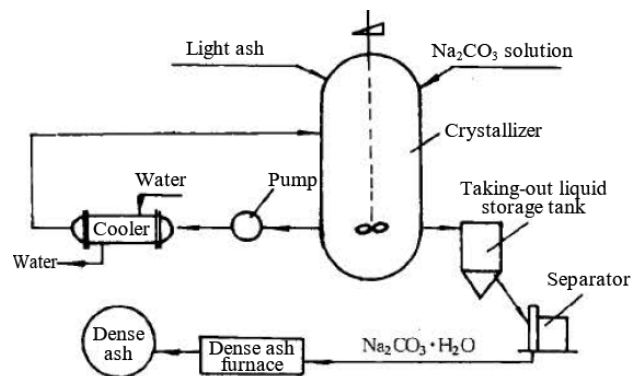


Figure 7-18 process flow diagram of preparing dense soda ash by crystallization method

7.2.8 Ammonia recovery

The ammonia used in the production by an ammonia soda process is recycled. The amount of ammonia required to prepare 1 t of soda ash is about 0.4-0.5 t. The ammonia added to the system will be lost due to escape, leakage by dripping, etc. In order to maintain a certain amount of circulating ammonia in the system, about 1.5-3 kg of ammonia needs to be supplemented for producing every 1 t of soda ash. It can be seen that reducing the loss of ammonia and recovering the ammonia as much as possible are very important in the production by an ammonia soda process. In the modern production by an ammonia soda process, various feed liquids containing ammonia are generally collected for ammonia recovery.

The ammonia-containing feed liquids mainly refer to filtered mother liquor and light liquor. The filtrated mother liquor contains “free ammonia” (about 25 tt) that can be decomposed and distilled by direct heating and “bound ammonia” (about 75 tt) that needs to be distilled after reacting with lime milk (or other alkali substances). Since the feed liquid also contains CO₂, in order to avoid unnecessary loss of lime, two steps are performed. First, the feed liquid is heated to draw out free ammonia and CO₂ in the liquid, and then lime milk is added to be reacted with the bound ammonia to convert it into free ammonia to be distilled out.

The furnace gas washing liquid, condensate, and other ammonia-containing impure water in the production are collectively referred to as the light liquor. The light liquor only contains free ammonia and thus the ammonia in the light liquor is relatively easy to recover. In order to reduce the load of a preheating section of an ammonia distillation tower, currently, the light liquor is mostly separated from the filtered mother liquor and heated and distilled in a light liquor distillation tower, and the ammonia is recovered.

The total volume of the mother liquor and the light liquor is about 6-7 m³/t soda ash, wherein the mother liquor is about 5.5-6.5 m³/t soda ash and the fresh liquid is about 0.5-1.0 m³/t soda ash.

(I) Process and equipment of ammonia distillation

The process of ammonia distillation is shown in Figure 7-19 and the main equipment is an ammonia distillation tower shown in Figure 7-20. The ammonia distillation tower comprises a mother liquor preheater, a preheating section and a lime distillation section.

The mother liquor preheater and the gas condenser are to recover heat and reduce water in ammonia gas. The mother liquor preheater and the gas condenser consist of 7-10 horizontal water tanks, hot gas is outside the pipe, and mother liquor or cooling water is inside the pipe. The cold mother liquor exchanges heat with the distilled hot gas in the mother liquor preheater, such that the mother liquor is heated from 25-32°C to about 70°C and then enters the preheating section. At the same time, the hot gas is cooled from 88-90°C to 65-67°C and then enters the gas condenser, wherein most of steam enters

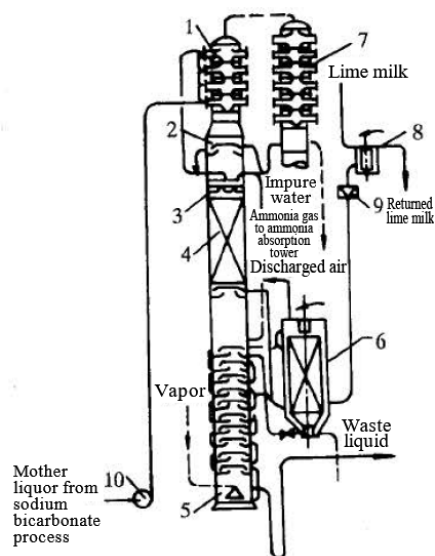


Figure 7-19 Process diagram of ammonia distillation

1-mother liquor preheater; 2-distillation section; 3-liquid separation tank; 4-preheating section; 5-lime milk distillation section; 6-prelimer; 7-gas condenser; 8-lime milk adding cylinder; 9-lime milk flow weir; and 10-mother liquor pump

an ammonia absorption tower after the condensation.

The preheating section is located in the middle of the tower and also known as a heater. Generally, various fillers or “liquid supporting tank” are used to achieve a better gas-liquid contact and increase the heat transfer surface. The mother liquor is added from an upper part through a liquid separation plate and directly contacts with the hot gas from a lower part, the contained free NH_3 and CO_2 are distilled out, and finally the mother liquor only containing bound ammonia and salt is left.

After the preheating section, since the bound ammonia in the mother liquor cannot be decomposed during the heating, the mother liquor is firstly introduced into the preliher from the tower to be mixed with lime milk. The preliher is provided with a stirrer to evenly mixing the mother liquor and the lime milk. At this time, most bound ammonia is converted into free ammonia, and then the mother liquor enters the lime milk distillation section of the tower for distillation. The lime milk distillation section is located at a lower part of the tower and internally provided with more than ten single cap-shaped bubble cap plates. The mother liquor containing lime milk from the preliher is added to the upper part of the section and in a countercurrent contact with the steam from the bottom of the tower. After the distillation section, 99% of the ammonia has been distilled out and waste liquid containing trace amount of ammonia is discharged from the bottom of the tower.

The heat required by the distillation tower is supplied by a low-pressure steam from the bottom of the tower and the steam consumption for producing 1 t of soda ash is 1.5-2.0 t.

In recent years, a Pall ring of $\phi 75 \text{ mm} \times 75 \text{ mm} \times 12 \text{ mm}$ reinforced by polypropylene glass fiber is used in the tower and has advantages of light weight, easy loading and unloading, and low breaking rate.

(II) Chemical reactions in process of ammonia distillation

The mother liquor is a solution containing various compounds. The main chemical reactions during the ammonia distillation process are as follows.

1. Reactions in preheating section

NaHCO_3 and Na_2CO_3 dissolved in the filtrated mother liquor are subjected to the following reactions:

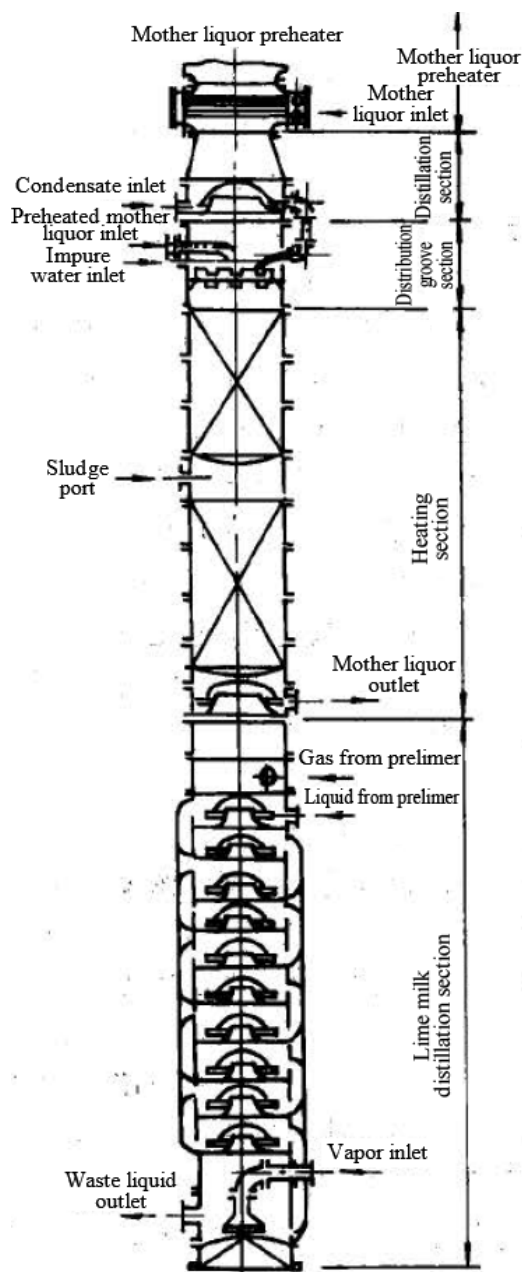
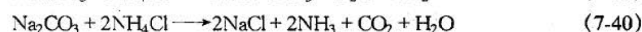
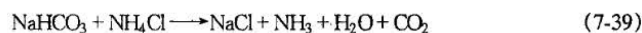
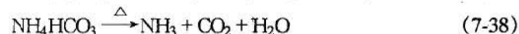
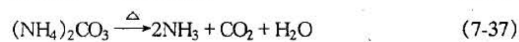
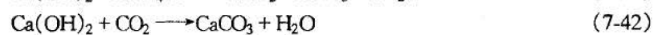


Figure 7-20 Ammonia distillation tower



2. Reactions in blending tank and lime milk distillation section



(III) Analysis of conditions of ammonia distillation process

Waste steam (0.16-0.17 MPa) with not too high temperatures and pressures is directly introduced from the bottom of the ammonia distillation tower. The amount of the water steam should enable the liquid temperature at the bottom of the preheating section to reach 100°C, so as to remove free ammonia and CO₂ as much as possible. Generally speaking, the steam consumption is (1.5-2) t steam soda ash. The temperature at the top of the tower is controlled by the amount of cold water in the condenser, and the temperature of the gas sent to the ammonia absorption system should be maintained at about 60-62°C. If the temperature is too high, the gas will bring too much water. If the temperature is too low, salts such as NH₄HCO₃ will crystallize out in the pipeline to cause blockage.

Decompression is beneficial for the ammonia distillation, such that the top of the tower is generally a slight vacuum of about 666 Pa. Although it can prevent escape loss of ammonia, it also produces the possibility of inlet of the air, such that the system should be closed to avoid diluting the ammonia gas to cause unfavorable absorption. The discharge of waste liquid under the tower is a decompression and isenthalpic process, such that a part of steam can be released to be used for preheating water to prepare lime milk; or the steam is introduced into a small distillation tower to distill out ammonia in various ammonia-containing impure waters. The ammonia loss and heat consumption in the waste liquid are proportional to the liquid volume, such that the liquid should not be too diluted, and the lime milk should be thicker and generally contains 180 tt of active CaO.

In order to distill out ammonia, the equilibrium partial pressure of ammonia in the liquid phase is required to be greater than the partial pressure of ammonia in the gas phase. Two special positions should be noted in this regard.

1. Position between preheating section and lime milk distillation section

The position is where the concentrated gas from the lime milk distillation section contacts with the liquid at the bottom of the preheating section. The ammonia in the liquid is all bound ammonia, its equilibrium partial pressure of ammonia should be equal to zero, and thus the ammonia in the gas phase will be partially dissolved in the liquid phase. This is the reason why the free ammonia in the solution at the outlet of the preheating section cannot be completely driven out.

2. Position at inlet of feed liquid

The ammonia gas escaping from the top part of the preheating section has a very high concentration and has a higher equilibrium partial pressure of ammonia than a newly added feed liquid. As a result, a part of ammonia will be re-dissolved into the feed liquid. Therefore, the feed liquid should be desirably added at a position where the partial pressure of ammonia in the gas phase is lower than its equilibrium ammonia vapor pressure, such that a driving force is positive for the distillation. The concentration of the hot condensate flowing down from the gas condenser is generally thicker. If it is returned to the top of the preheating section without passing through the light liquor distillation tower, the condensate will be diluted by an inlet feed liquid, and thus a part of ammonia and CO₂ is evaporated and condensed repeatedly to waste heat energy.

The amount of waste liquid discharged from the bottom of the ammonia distillation tower is about 7-10 m³ for producing every 1 t of soda ash. According to the vapor pressure at the bottom of the distillation tower, the temperature of the waste liquid is 90-120°C. In addition to NaCl and CaCl₂, the waste liquid also contains a trace amount of NH₃. There are also a small amount of Ca(OH)₂, CaCO₃ and CaSO₄, some of which are dissolved and some are suspended solids. In addition, the rest is almost the sand brought into the ammonia distillation tower by the lime milk.

(IV) Light liquor distillation

The light liquor distillation process is also a process of "stripping" directly with water vapor, ammonia and CO₂ are distilled out by direct heat and mass transfer, and they can be returned to the production system for reuse. In actual production, since the calcined furnace gas condensate and ammonia-containing impure water

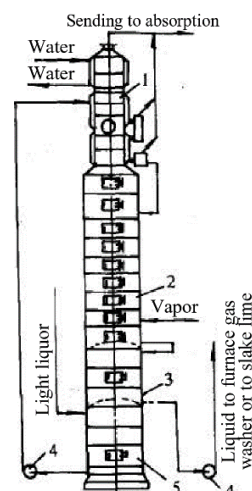


Figure 7-21 Process flow chart of light liquor distillation

1-light liquor distilled gas condensing-cooling machine;
2-light liquor distillation tower; 3-degassed liquid storage tank;
4-pump; and 5-light liquor storage tank

contain a small amount of soda ash, even if there is a small amount of “bound ammonia” in the impure water, it will be converted into free ammonia. Therefore, the light liquor is an $\text{NH}_3\text{-CO}_2\text{-H}_2\text{O}$ system without NaCl and NH_4 . The main reaction of the distillation process is the same as that of the heating section. The process is shown in Figure 7-21.

The light liquor produced by the production of soda ash is collected in a storage tank 5 and then sent to a cooling section of a light liquor distilled gas condensing-cooling machine 1. The light liquor passing through the light liquor distilled gas condensing-cooling machine at $73\text{-}77^\circ\text{C}$ enters a light liquor distillation tower by a distribution tower plate. In the light liquor ammonia distillation tower, NH_3 and CO_2 are desorbed by a mixed gas of liquid convection vapor and gas. The mixed gas of liquid convection vapor and gas passes through the light liquor ammonia distillation tower, passes through the light liquor distilled gas condensing-cooling machine, and is sent to absorb ammonia at $58\text{-}60^\circ\text{C}$. The liquid passing through the light liquor ammonia distillation tower is collected in a degassed liquid storage tank and sent to a kiln gas washer or a vacuum filter using a pump 4.

7.2.9 Overall process of production by ammonia soda process

The overall process of production by an ammonia soda process is shown in Figure 7-22. The relationships between various processes in the production process can be seen.

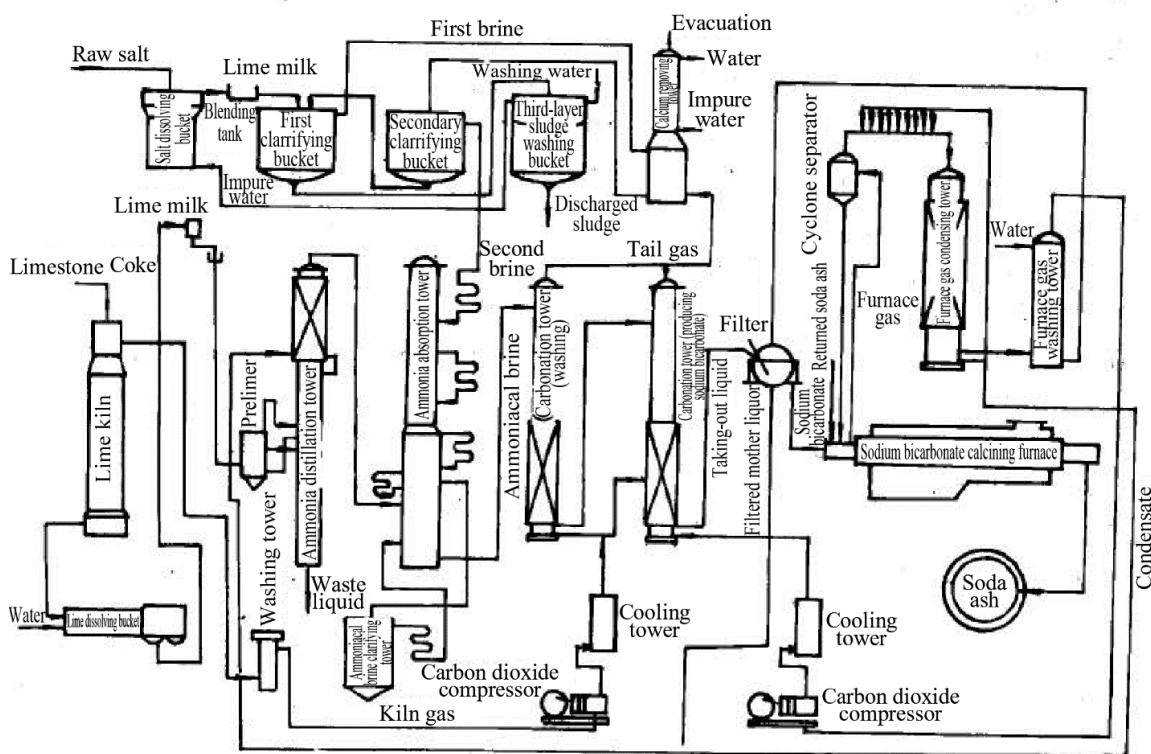


Figure 7-22 Overall process of preparation of soda ash by ammonia soda process

7.2.10 Processing of secondary material resources in preparation of soda ash by ammonia soda process

With the rapid development of the industry, environmental pollution destroys the original dynamic balance of the nature and seriously threatens the survival and development of human beings. Therefore, the research on improving the environmental quality is started or carried out in our country and even all over the world. In chemical production, it is desirable to have a waste-free process, that is, to ensure that the natural resources are fully and optimally utilized when a certain product is required, solid and liquid wastes are not discharged into open water areas or storing areas, and harmful waste gases are not discharged into the atmosphere. However, it is very difficult to carry out such a process, particularly for the large-tonnage production of soda ash by an ammonia soda process. At present, the environmental pollution can only be alleviated and cannot be completely eliminated, such that only a less-waste process can be established.

When the less-waste process is established, the natural resources are fully utilized to ensure the demand for specified products, that is, the secondary material resources are processed, harmful wastes are not discharged into the atmosphere and water system, and heat loss to the surrounding environment should be minimized.

When the waste is reduced as much as possible, the production process should be intensified and the production benefit improved. For example, increasing the completeness of the production process (by selecting optimal conditions to increase the utilization rate of sodium in the carbonation) can increase production efficiency and reduce the amount of wastes. Therefore, establishing a waste-free process is a reasonable approach, both technically and economically, to solve the problem of environmental protection, and is also a main approach.

So far, the following main directions have been identified in establishing the less-waste process:

- (1) studying and developing a process system and a water circulation system to ensure that discharge of a liquid waste and harmful waste gas meets discharge standards of the local region;
- (2) processing secondary material resources into useful products;
- (3) recycling secondary energy and reducing environmental heat loss; and
- (4) establishing a regional industrial complex with closed structures for raw materials and wastes within the enterprise.

The discharges in the production process cycle of soda ash by an ammonia soda process are: distilled suspensions capable of being separated into clarified liquid and solid residues; waste residues during brine refining process; and gaseous wastes

If the harmful substances contained in the gaseous wastes are within an allowable standard range, they can be discharged into the atmosphere. But the clarified distillate and solid residues can be processed into products beneficial to human economic activities and should be regarded as secondary material resources.

The production of a wide variety of products can realize a closed structure for utilizing the raw materials and waste materials. It should be noted that the demand for calcium chloride has grown in recent years and is equivalent to the demand for soda ash. The demand for products produced with solid secondary material resources (waste residues) exceeds the annual output rate of the secondary material resources produced by soda ash.

(I) Production of calcium chloride and refined salt

When the less-waste soda ash production complex is established, an efficient process for processing the clarified distillate can be promoted. The clarified liquid can be processed to produce calcium chloride or injected into oil wells after corresponding treatment.

The distillate is an aqueous solution of inorganic salts and its main components are CaCl_2 (10%-14%) and NaCl (5%-7%). The methods for preparing calcium chloride while separating sodium chloride described below are all based on concentrating the aqueous solutions of these salts.

The use of the prepared calcium chloride in the national economy is based on its high water absorption, that is, it can absorb a large amount of water in the air and is easily soluble in water. The calcium chloride has a freezing point lower than water and a boiling point at a concentrated solution higher than water (for example, a 30% CaCl_2 solution freezes at -55°C and boils at 111.6°C).

The calcium chloride is mainly consumed in chemical industry (synthetic rubber production, flotation, etc.), refrigeration engineering, construction industry (improving a solidification rate of concrete), non-ferrous metallurgy (preparing calcium-containing Babbitt metal), and ore processing (to prevent freezing). The calcium chloride can be also used in the textile industry and other sectors of the national economy.

The by-product sodium chloride is mainly consumed in agriculture (preparing a compound feed and a mixed feed) and sometimes NaCl is returned to the production process for preparing soda ash.

1. Main properties of calcium chloride

The calcium chloride dissolves in water, which is an exothermic process. In a temperature range of practical value, its solubility is:

t, ($^\circ\text{C}$)	60	80	90	100	120	140	160	170
C, (weight%)	57.8	59.5	60.6	61.4	763.4	65.6	69.0	71.8

When industrial molten calcium chloride is prepared from the distillate, a solution containing about 70% CaCl_2 can be obtained within a temperature range of $179\text{--}188^\circ\text{C}$. This solution is slightly cooled to crystallize calcium chloride dihydrate. The following is the relationship between the boiling point and concentration of the calcium chloride aqueous solution:

c_{CaCl_2} (weight%)	70	71	72	73
Boiling point, ($^\circ\text{C}$)	165	168	171	173

2. Production process of refined salt is shown in Figure 7-23.

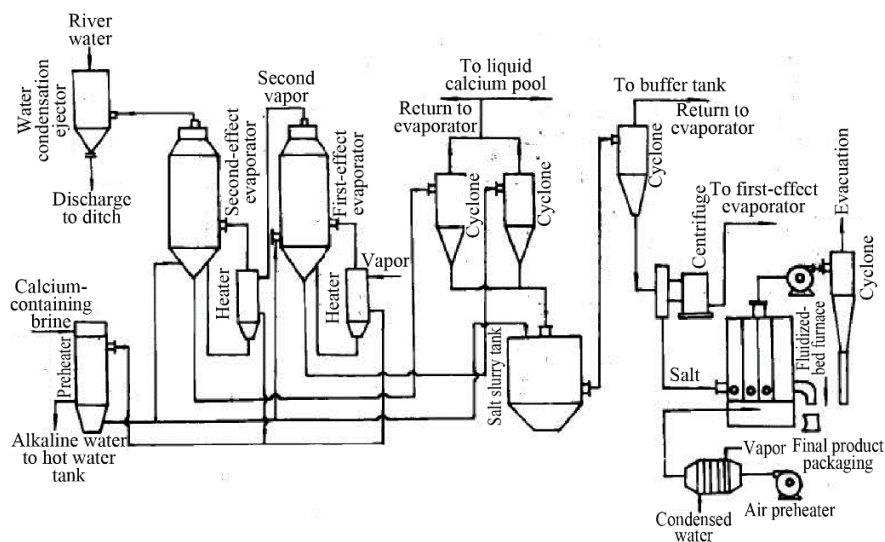


Figure 7-23 Production process of refined salt

The waste liquid of the ammonia distillation tower in the ammonia soda factory is clarified to remove impurities, then crude salt is dissolved to form the liquid, calcium-containing brine, the liquid enters this process and is preheated by a preheater, then the preheated liquid enters double-effect evaporators for evaporation and concentration, and refined salt crystals are precipitated at the bottoms of the evaporators and sent to cyclones for separation. The crystals from the bottoms of the cyclones are sent to a slurry tank and the calcium chloride is washed away with brine; and The liquid at the tops of the cyclones is returned to the evaporators or a liquid calcium pool. The salt in the salt slurry tank will be separated into salt crystals by a cyclone, water is further removed by a centrifuge, and then the salt is dried in a fluidized-bed drying furnace to obtain a refined salt product.

3. Production process of calcium chloride is shown in Figure 7-24.

The liquid calcium from the salt production process enters the liquid calcium pool, is pumped into a liquid calcium tank, then enters bottom parts of rising film evaporators to be concentrated, and enters separators from top parts of the rising film evaporators for separation. Water vapor from the top parts of the separators is condensed by a jet condenser and then enters a sewer. The liquid calcium from the bottom parts of the separators is sent to falling film evaporators for further heating and concentration, and the concentrated calcium chloride from the bottoms of the falling film evaporators enters a storage tank and packaged into a barrel to obtain 70% solid calcium chloride. If one calcium chloride binds to two crystal water, the calcium chloride is called water calcium chloride.

The liquid calcium from a clarification tank of an accumulation yard enters a high brine tank, self-presses into the preheater and heated by a condensate of the rising film evaporators, then enters the rising film evaporators to be heated and concentrated, and then enters the separators for separation, and the liquid calcium enters the liquid calcium pool.

For example, the 70% solid calcium chloride is broken into small blocks and dried again on a drying pit to obtain anhydrous calcium chloride.

The production of refined salt and calcium chloride is introduced above, and is completed by two processes separately. The consumption quota is:

fire coal 300 kg/t_{refined salt}; 800 kg/t_{70% calcium chloride}; 1200 kg/t_{anhydrous calcium chloride}; and
crude salt 800 kg/t_{refined salt}

The crude salt is consumed when the refined salt is produced by this method. The rising and falling film evaporators are used during production of the calcium chloride, thus the evaporators are relatively seriously corroded by the concentrated hot calcium chloride solution. A method for preparing calcium chloride from the waste liquid of the ammonia distillation tower and simultaneously separating NaCl is introduced below. The method can overcome the shortcoming.

4. Process of preparing calcium chloride and simultaneously separating NaCl is shown in Figure 7-25.

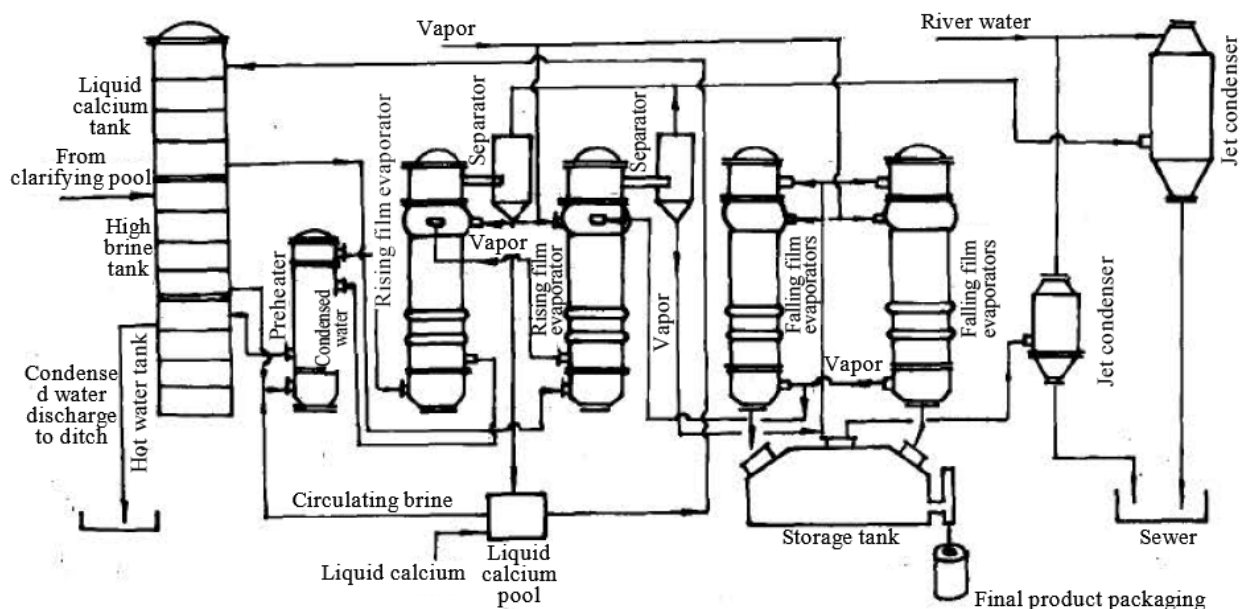


Figure 7-24 Production process of calcium chloride

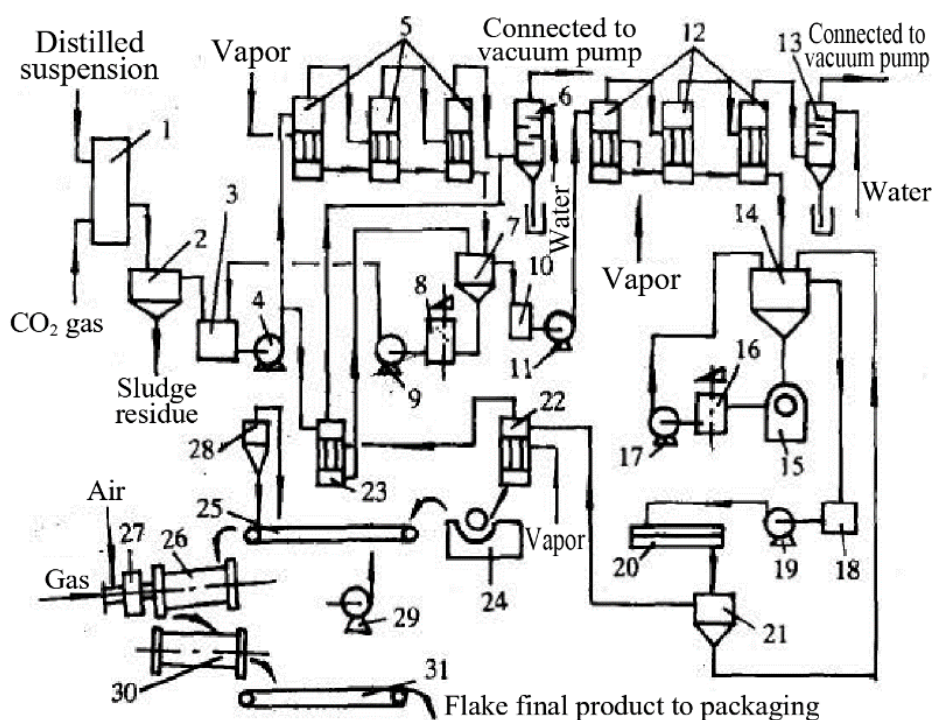


Figure 7-25 Production flow diagram of calcium chloride

1-carbonizer; 2, 7, 14, 21-precipitator; 3, 8, 18-container; 4, 9, 11, 17, 19-pump; 5, 12-evaporator; 6, 13-mixing condenser; 10-storage tank; 15-centrifuge; 16-separated liquid storage tank; 20-vacuum crystallizer; 22-evaporator; 23-waste heat utilization device; 24-flake forming machine; 25, 31-conveyor belt; 26-hardening device; 27-combustion chamber; 28-cyclone separator; 29-fan; and 30-cooling rotary cylinder

A distilled suspension entering a calcium chloride workshop is first pre-carbonized with gas containing CO_2 in a carbonizer 1, and then sent to a precipitator 2 to settle suspended particles (double sedimentation can also be provided before and after carbonation). The sediment (solid phase) is sent to the precipitator for further processing to produce a calcareous soil conditioner and a feed additive. The clarified solution flows into a container 3. A seed crystal active anhydrite CaSO_4 is added into the container at the same time to prevent scaling of heat transfer surfaces of an evaporator group.

The clarified distillate containing the seed crystal is sent from the container 3 to a triple-effect co-current evaporator group 5 by a pump 4, where the liquid is concentrated by evaporation to contain 18% CaCl_2 . The suspension from the last-effect evaporator flows into a precipitator 7. The thick suspension used as a seed crystal passes through a container 8 equipped with a stirrer and is sent back to the container 3 by a pump 9 to be continuously used as a seed crystal.

The partially concentrated and deseeded distillate is sent from a storage tank 10 to a second triple-effect co-current evaporator 12 by a pump 11. Here, the distillate is concentrated to contain 38% calcium chloride and a main part of sodium chloride is separated. The last effects of the evaporators 5 and 12 are both performed under vacuum. Secondary steam from the last effects enter mixing condensers 6 and 13. Air and non-condensed vapor are drawn from the condensers with vacuum pumps (not shown in the figure). The amount of condensed water generated in the evaporators is $5.5 \text{ m}^3/\text{t}_{\text{soda ash}}$ (calculated based on the production of 67% calcium chloride), and the condensed water is sent to a brine preparation field, and thus the water consumption can be appropriately reduced.

The sodium chloride suspension in the 38% calcium chloride solution flows into a precipitator 14, a thick part then enters a centrifuge 15 from the precipitator, and solid sodium chloride is sent to the user or returned to soda ash production. The separated liquid passes through a storage tank 16 and is sent back to the precipitator 14 by a pump 17. The clarified 38% calcium chloride solution is put into a container 18 and then pumped to an absorption pipeline of a circulating pump of a vacuum crystallizer. In the vacuum crystallizer 20, the solution is further concentrated to contain 40% CaCl_2 and at this time, the remaining amount of sodium chloride is precipitated into a solid phase. The sodium chloride suspension in the 40% calcium chloride solution is sent to a salt mud precipitator 21 by the vacuum crystallizer. The thick salt slurry then enters the precipitator 14 again.

In some production processes of calcium chloride, the vacuum crystallizer is replaced by an evaporator group, that is, the evaporators are used to concentrate CaCl_2 to 48%, and then the sodium chloride is separated.

The clarified 40% calcium chloride solution is sent to an evaporator 22 at a normal pressure, where the solution is concentrated to a molten state and contains 72% CaCl_2 . The secondary steam of the evaporator 22 is used to heat a waste heat utilization heat exchanger 23 operating in parallel with the evaporators 5. The calcium chloride melt is fed into a groove of a flake forming machine 24 and cooling water is added to a rotary cylinder of the flake forming machine for cooling. The coarse flakes are scraped off from the rotary cylinder with a scraper and fed into a hardening machine 26 with a conveyor belt 25, and the flakes are dried by counter currently passing flue gas. The flue gas comes from a combustion chamber 27 which burns a mixture of natural gas and air. The flue gas passing through the hardening rotary cylinder enters a cyclone dust separator 28 and then is extracted by a fan 29 and discharged into the atmosphere.

The hot flakes containing the main substance of about 78% CaCl_2 are discharged into a cooling rotary cylinder and the rotary cylinder wall is cooled with circulating water. The cooled final product flakes are conveyed by a conveyor for packaging and then transported into a final product warehouse.

The main devices of this process are:

The distilled suspension is carbonized using a hollow carbonizer with a lower bubbler. The carbonizer has a diameter of 3.0 m, an effective height of 17 m, and an effective volume of 119 m^3 .

The distilled suspension is clarified using a standard gravity-type precipitator.

Evaporators are of the same model with an external heating chamber and a boiling zone. Each device has a heating surface of 384 m^2 .

The seed crystal is precipitated in a centrally driven gravity-type single-layer thickener. The thickener has a diameter of 25 m and a settling surface of 500 m^2 .

A melting device is a Robert evaporator with a heating surface of 350 m^2 and an average heat transfer coefficient of $430 \text{ W}/(\text{m}^2 \cdot \text{K})$. A temperature difference between a working medium and a heat carrier is 20°C . The device has a diameter of 2.4 m and a height of 10.1 m.

A vacuum crystallizer has an outer diameter of 2.4 m, a height of 18.15 m, and a volume of 32.7 m^3 .

A rotary cylinder-type countercurrent dryer for drying calcium chloride flakes has a volume of 60.8 m³, a diameter of 2.2 m and a length of 16.0 m. An average temperature difference between a working medium and a heat carrier is 200°C. The heat carrier is a combustion product of gaseous fuel.

A rotary cylinder-type cooler has a diameter of 2.5 m and a length of 25 m. Air and water are used as a working medium to cool the flakes.

All the devices are standard products.

(II) Production of soil conditioners and inorganic feed additives

In order to maturing acidic and alkaline soils and improve fertilizer efficiency, calcareous soil conditioners need to be applied to the soil.

It is also important to produce inorganic feed additives based on calcareous substances.

According to data, a soil conditioner made from carbonate products derived from production of soda ash is effective as lime powder, gypsum, chalk and other conditioners, even more effective since a calcium ion in a solid (slag) phase of the distilled suspension has a relatively high activity, and the conditioner has a better physical state and contains magnesium sulfate.

The application of the soil conditioner has a good effect on the physical and chemical properties of the soil, changes reaction of a soil solution, reduces a hydrolysis acidity, and increases a pH value from 5.5-5.6 to 6.2-6.4. The soil conditioner reduces soil dispersion and mobility of organic matters, especially in spring. The soil conditioner improves a structure of an arable layer and reduces the adhesion of the soil by $\frac{1}{2} - \frac{1}{3}$.

The inorganic feed additives can also effectively replace chalk in an agricultural feed for poultry and livestock.

1. A production process of the soil conditioner is shown in Figure 7-26.

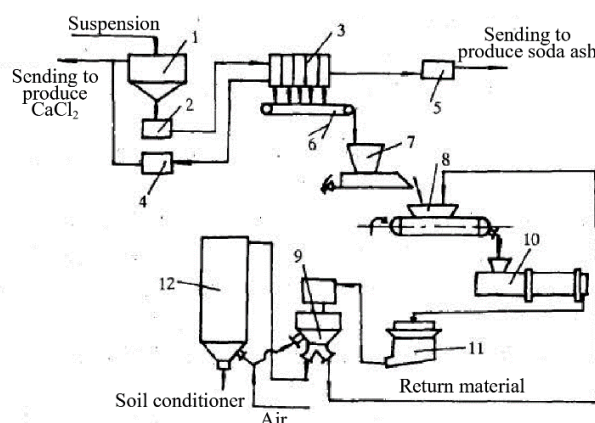


Figure 7-26 Production flow diagram of soil conditioner

1-precipitator; 2-intermediate container; 3-chamber filter press; 4-filtrate storage tank; 5-washing water storage tank; 6-conveyor; 7-vibratory metering feeder; 8-mixer; 9-pneumatic device; 10-rotary drum dryer; 11-hammer crusher; and 12-silo

A suspension from a distillation tower enters a precipitator 1, the clarified part is sent from here to produce calcium chloride, and the thick part is sent into an intermediate container 2 and then enters a chamber filter press 3. The filtrate is sent from a storage tank 4 to produce calcium chloride. Recovered liquid for washing the filtrate and the filter cloth is collected in a container 5 and sent to slake lime, prepare lime milk and perform other processes.

The filtered residue is fed into a vibratory feeder 7 by a conveyor 6 and then enters a mixer 8. A part of the final product is also sent to the mixer as a return material (at a ratio of the final product to the residue of 1 : 1.5). The wet residue and the return material are mixed and then sent to a rotary drum dryer 10 to be dried to a moisture content of 8%. After the drying, the material is crushed by a hammer crusher 11 and sent to a pneumatic device 9, and then enters a silo 12 and is sent to the user from here.

The main device of this process is:

A precipitation thickener has a diameter of 40 m and a standard settling surface of 1,250 m².

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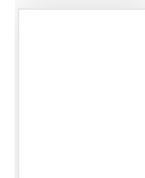
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Waste-Free Technological Processes **A New Mode of
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Waste-Free Technological Processes

-A New Mode of Industrial Development

Xi Deli



Tsinghua University Press

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Summary of Content

It is an urgent task for mankind today to make rational use of resources and protect the environment. The newly developed waste-free technological processes are a new industrial development mode for realizing the harmony and unity of society and nature.

This book introduces in detail the main contents of waste-free technological processes in specific industrial sectors, such as minerals, ferrous metallurgy, nonferrous metallurgy, petroleum refining, chemicals and electric power.

The book is divided into seven chapters: Chapter I Industrial Development and Its Ecological Consequences; Chapter II Natural Resources and Their Utilization; Chapter III Theoretical Basis of Waste-Free Technological Processes; Chapter IV Main Ways to Realize Waste-Free Technological Processes; Chapter V Direction and Progress of Establishing Waste-Free Production in Major Industrial Sectors; Chapter VI Establishing Waste-free Industrial Zones; and Chapter VII Economic Evaluation of Waste-Free Technological Processes.

The book is rich in content, and smooth and vivid in narration.

The book can not only serve as a teaching material for environmental protection majors, but also be used as a reference for personnel engaged in industrial and environmental protection planning, design and technological process research.

Waste-Free Technological Processes

—A New Mode of Industrial Development

Xi Deli



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Sludge This process is completely different from ammonia-soda process from raw materials to technological process, and can basically enable waste-free production, which has been introduced in the previous chapter.

(2) Comprehensive Utilization and Harmless Treatment of Distillation Waste Liquor and Waste Residue

① Recovery of CaCl_2 and NaCl from Distillation Waste Liquor After clarification, the distillation waste liquor is first treated to remove SO_4^{2-} , next evaporated to separate out NaCl , then washed and centrifugally dewatered, and finally is used as a salt product or reused in alkali production. The mother liquor contains CaCl_2 (32–38%), and may be directly provided to users as a product, or be continuously evaporated to further remove NaCl , and finally a solid product $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ is obtained. The CaCl_2 may be used as a hygroscopic agent for gas and liquid in chemical industry and as an additive for concrete, a building material. The research indicates that adding CaCl_2 into cement burden can reduce the calcination temperature by 350-500°C, thereby correspondingly saving fuel by 30%. In addition, the cement clinker produced at a lower temperature is easy to grind, and the concrete prepared with this cement has a higher grade.

② For making use of alkali residues to produce cement and other building materials, and making use of waste residues in alkali production, such as insoluble solid residues in distillation waste liquor, brine sludge and limestone calcination tailings, to produce cement, the key lies in meeting dechlorination requirements and proper proportioning ratios so as to ensure product quality and reduce energy consumption.

Alkali residues may also be mixed with sulfuric acid-containing wastewater discharged from nearby chemical plants in a certain ratio to produce alkali residue • β -dihydrate gypsum. By different heat treatments, different alkali residue gypsum can be obtained, such as alkali residue • α -hemihydrate gypsum, which can be used as interior decoration materials.

③ Preparation of Calcium–Magnesium Fertilizers from Alkali Residues This kind of calcium-magnesium fertilizer may replace lime as a conditioner for acidic soil, and can increase the land fertility and the yield of rice, peanuts, soybeans, corn, barley and other crops. According to the preparation method, the distillation waste liquor is first thickened until the solid-liquid ratio is 1 : 10, and then filtered by a filter press. Part of Cl^- is washed off on the filter press, and the filter cake contains 5% water, which is mixed with chalk tailings at a ratio of 1 : (2-3), crushed and then dried.

④ Preparation of Poultry Feed Additive from Alkali Residues After the chloride in the waste residue is removed to below 4%, the residue can be used as an inorganic salt additive for poultry feed to improve the laying rate of poultry.

(3) Other Measures

① Establishment of a water circulating system. Using the purified wastewater to dissolve salt, and part of the distillation waste liquor to digest quicklime. Using the dry quicklime to replace lime milk in ammonia distillation, and changing water cooling to air cooling to reduce water consumption.

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Compiled by Beijing Editorial Department of China Southern Book Company

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the loss, 25% or more of the salt was wasted. As a result, the existing alkali plants adopting ammonia-soda process all have the cheapest and most abundant supply of raw salt. In this case, it is often uneconomical to recover salt from waste liquor of distillation. However, the purity of the salt thus recovered is very high, which is comparable to the salts refined by soda lime method and made from water. The recovered salt is connected with the preparation of calcium chloride.

We will discuss several main products that have been produced on industrial scale from waste liquor of distillation, namely, refined salt, calcium chloride, calcium sulfate and ammonium chloride.

Refined salt and calcium chloride:

In production using ammonia-soda process, it is hoped that the volume of waste liquor of distillation should be as small as possible, especially when some substances in the waste liquor need further processing. To this end, the decomposition rate in the carbonation tower should be as high as possible to make the volume of filtrate as small as possible; on the premise of ensuring that the salt content in soda is within the permissible range, the washing water of filter should be as little as possible; and concentrated lime milk containing 250 g CaO per liter (with the specific gravity being 1.21) should be used, or solid lime should be added into the pre-ash bucket for distillation. The liquid containing a little excessive free lime is carbonized by introducing some waste CO₂ gas. By clarification, the precipitated CaCO₃ and all solid substances in the liquid are separated. The clear solution containing CaCl₂, NaCl and a small amount of dissolved CaSO₄ is concentrated in a triple-effect evaporator until NaCl and a small amount of CaSO₄ begin to precipitate and crystallize. The salt crystals are filtered out in a centrifuge, and a small amount of water is sprayed on the filter cake of the salt to wash off the CaCl₂ in the salt. The salt from the centrifuge can be directly packed in barrels without further drying.

Evaporation of the liquid should be carried out until the specific gravity of the liquid in the last effect of the evaporator reaches 42 °Bé. In this case, almost all salt can be precipitated. A little "chlorinated lime" is added to oxide the iron before clarification. The clarified solution is further concentrated in a cast iron pan until the molten substance solidifies when being cooled to obtain a product called 75% calcium chloride, the corresponding molecular formula of which is CaCl₂•2H₂O. This product is scooped into iron drums, each of which holds about 600 pounds. The iron drums should be sealed. The typical components of this product are as shown in Table 9:

Composition of 75% CaCl ₂ (%)			Table 9
CaCl ₂	73.6	Insolubles	0.08
NaCl	1.4	Water	24.92

To prepare anhydrous CaCl_2 , 75% CaCl_2 is heated in a reverberating furnace or a stirring furnace, and the molten substance is frequently raked until part of CaCl_2 is decomposed to generate CaO and HCl . The HCl gas escapes, leaving the molten porous CaCl_2 , called 95% calcium chloride. The cooled anhydrous calcium chloride, which is slightly fluorescent, is packed in iron drums or paper-lined wooden barrels and sealed.

The calcium nitride solution can be used as a refrigerant or antifreeze in ice making process; the 75% solid calcium chloride is used as a dust suppressant to reduce dust on roads. The anhydrous calcium chloride can be used as a catalyst for preparing calcium cyanamide by reacting calcium carbide with nitrogen, where the reaction is possible at a low temperature.

Calcium sulfate:

Crystalline $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ is called "Crown Filler" in products made by Solvay process, which is far purer than natural gypsum. The manufacturing process includes settling the waste liquor from ammonia distillation tower, and treating the clarified liquid with salt cake while it is hot. The excessive free lime contained in the solution is neutralized by a trace amount of sulfuric acid in the salt cake. If the obtained solution is slightly acidic, some lime milk may be added. The precipitated $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ is filtered by a vacuum drum filter, and then dewatered by a centrifuge, on which a small amount of water is poured to wash away the soluble salt. The gypsum crystals obtained are dried at low temperature, which is roughly like drying of sodium bicarbonate. The calcium sulfate is used as a filler for papermaking.

If drying is carried out at 190°C or lower, calcined gypsum $\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$ is obtained, which can be used for making models and wall powder, and has many applications in the construction industry. If burning is carried out at above 200°C or above, all water will escape, but care must be taken not to reduce sulfate to sulfide. If containing trace iron, it will be dyed yellow after calcination. The calcined calcium sulfate is used to make a certain toothpaste and wall and floor coatings.

The filtrate, after removal of precipitated calcium sulfate, is a very pure bittern, which may be sent to an alkali plant to be made into a saturated bittern for use in alkali manufacture.

Ammonium chloride:

Ammonium chloride is produced by making calcium chloride solution obtained from waste liquor of distillation react with ammonia and CO_2 . To this end, the waste liquor of distillation is clarified, the solids are removed, and then the solution is concentrated in an evaporator to 40°Be . Now, the content of CaCl_2 in the solution reaches about 50%. The precipitated salt is filtered out, and the calcium chloride solution is put into a jar with a stirrer, and ammonia gas is introduced...

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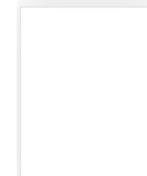
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charged dust particles are trapped on the dust collecting plate. At present, tube-type or tube-plate dust collectors are widely used.

(1) Treatment of lime dust and alkali dust by tube-type high-pressure electrostatic precipitators. A GZD 100 kV/20 mA single-tube electrostatic precipitator is used in the calcination workshop of Qingdao Soda Plant, which is installed above the alkali screen. After dust removal, the exit gas enters the cabin for further removal of alkali dust, and then is discharged into the atmosphere from the roof. A CGB 100 kV/0.02 A electrostatic precipitator is used in the lime workshop, which is installed at the top of the lime hoist.

By using the electrostatic precipitator, the alkali dust in the exit gas of the alkali screen in the calcination workshop is reduced from 6000 mg/m³ to 300 mg/m³; the dust of the lime hoist is reduced from 3097 mg/m³ to 150 mg/m³, with a recovery of 95%.

(2) Treatment of lime dust discharged from the top of the lime kiln by a horizontal dust collector. The soda plant of Dalian Chemical Industry Company uses a BG-30m² horizontal electrostatic precipitator to treat the vented kiln gas. The removed dust is subjected to vibration dust cleaning by a rocker hammer, humidified by seawater, and transported out of the factory by truck, and the de-dusted kiln gas is sucked by a draught fan and discharged into the atmosphere through a chimney. By using the collector, the dust content is reduced from 300-5000 mg/m³ to 10 mg/m³, with a dust removal efficiency of 99.5%.

Section III Comprehensive Utilization of Wastes to Produce Chemical Products

The treatment of waste liquors and residues from ammonia alkali plants at the cost of investments for effective measures can certainly solve the problem of environmental pollution. However, it does not solve the problem of resource loss, and moreover, it increases the costs of products to varying degrees, thereby reducing the economic benefits of enterprises. As mentioned in the forgoing section, the treatment of waste liquors and waste residues in some ammonia alkali plants, such as the alkali plant of Dahua Company, increases the product cost by 6.3 - 13.2 yuan/ton of soda ash (sodium carbonate). Therefore, it is not a fundamental solution. The fundamental way to treat waste liquors and waste residues is to comprehensively utilize the wastes so as to turn the wastes into treasure for benefiting the people. The comprehensive utilization in some ammonia-alkali plants in China is described below.

I. II. Preparation of Calcium Chloride and Refined Salt from Waste Liquors

When calcium chloride is prepared from distillation waste liquor, refined salt can be produced as a by-product.

1. Physical and chemical properties and uses of calcium chloride

The general properties and uses of calcium chloride are shown in Section I of Chapter I. Calcium chloride absorbs moisture strongly in the air and deliquesces. The relative humidity of the air above CaCl₂•2H₂O is 22% at 20°C and 17% at 50°C. The equilibrium relative humidity of the air above CaCl₂•6H₂O is 32.3% at 20°C and 31% at 24.5°C. When the gas is dried with granular calcium chloride at 25°C, the moisture in the gas can be reduced to 0.14 - 0.25 g/m³. The actual water holding capacity (surface layer) of calcium chloride at 25°C is:

Relative humidity of gas/% 36 60 70 80 85 90 95

Water holding capacity/(kg/kg) 1.0 1.6 2.2 2.8 3.5 5.0 8.1

Calcium chloride has anhydrous and four hydrate forms, and their properties are listed in Table 16-2.

CaCl₂ dissolved in water can form a high concentration solution, and hydrate can be precipitated at a certain temperature. The relationship between the concentration and temperature of CaCl₂ is shown in Table 16-3 and Figure 163.

Table 16-2 Properties of Pure Calcium Chloride and Its Hydrate

Property	CaCl ₂	CaCl ₂ •H ₂ O	CaCl ₂ •2H ₂ O	CaCl ₂ •4H ₂ O	CaCl ₂ •6H ₂ O
ω CaCl ₂ /%	100.00	86.03	75.49	60 ± 63	50.66
Relative molecular mass, M_r	110.99	129.01	147.02	183.05	219.08
Melting point mp/°C	772	260	176	45	30
Boiling point bp/°C	1670	-	-	-	--
Density (25°C)/g/cm ³	2.22	2.24	1.85	1.83	1.72
Heat generated (18 °C)/(kJ/kg)	-7190	-8610	-9490	-10980	-11911
Heat of melting/(kJ/kg)	256(772°C)	-	-	-	170(30°C)
Heat of hydration (anhydrous salt)/(kJ/kg)	-	-240	-295	-600	-840
Heat of dissolution ^① /(kJ/kg)	-680	-380	-290	-50	80
Specific heat capacity/[J/(kJ • K)]	670	840	1170	1310	1420

① Except for monohydrate, a case where 300mol of water is used, for other hydrates, 400mol water is used for 1mol solute.

Table 16-3 CaCl_2 Solubility in Water

Temperature °C	$\omega\text{CaCl}_2/\%$	Solid phase	Temperature °C	$\omega\text{CaCl}_2/\%$	Solid phase
-49.8	30.5	$\text{Ice} + \text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	50	56.9	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
-25	33.4	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	75	59.1	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
0	37.3	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	100	61.3	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
20	12.7	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O}$	125	63.7	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
30	50.0	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O} + \alpha\text{-CaCl}_2 \cdot 4\text{H}_2\text{O}$	150	67.2	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$
29.5	52.4	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O} + \beta\text{-CaCl}_2 \cdot 4\text{H}_2\text{O}$ (metastable)	175.5	74.9	$\text{CaCl}_2 \cdot 2\text{H}_2\text{O} + \text{CaCl}_2 \cdot \text{H}_2\text{O}$
29.2	53.0	$\text{CaCl}_2 \cdot 6\text{H}_2\text{O} + \gamma\text{-CaCl}_2 \cdot 4\text{H}_2\text{O}$ (metastable)	200	75.7	$\text{CaCl}_2 \cdot \text{H}_2\text{O}$
40	53.6	$\alpha\text{-CaCl}_2 \cdot 4\text{H}_2\text{O}$	260	77.7	$\text{CaCl}_2 \cdot \text{H}_2\text{O} + \text{CaCl}_2$
45.3	56.5	$\alpha\text{-CaCl}_2 \cdot 4\text{H}_2\text{O} + \text{CaCl}_2 \cdot 2\text{H}_2\text{O}$	300	80	CaCl_2

Table 16-4 Relative Density (15°C) and Freezing Point of Commercial Calcium Chloride Solution

$\text{CaCl}_2/\%$	Relative density (15°C)	Freezing point/°C	$\text{CaCl}_2/\%$	Relative density (15°C)	Freezing point/°C
0	1.000	0	16	1.145	-11.56
2	1.018	-0.89	18	1.165	-14.50
4	1.034	-1.89	20	1.386	-18.00
6	1.052	-2.89	25	1.239	-29.44
8	1.069	-4.11	30	1.295	-46.00
10	1.087	-5.39	32	1.317	-28.61
12	1.105	-7.06	33	1.328	-21.61
14	1.125	-9.16	34	1.340	-15.39

High concentration calcium chloride solution has a lower crystallization temperature. By using this property, a concentrated calcium chloride solution (brine) is often used as a low-temperature freezing medium. Table 16-4 lists the data of concentration, relative density and freezing point of calcium chloride solutions.

The recovery of calcium chloride and salt from distillation waste liquor follows the phase diagram of CaCl_2 and NaCl binary system. The solubilities of NaCl - CaCl_2 - H_2O systems are listed in Table 16-5 and shown in Figure 16-4.

2. Product Specification and Consumption Quota

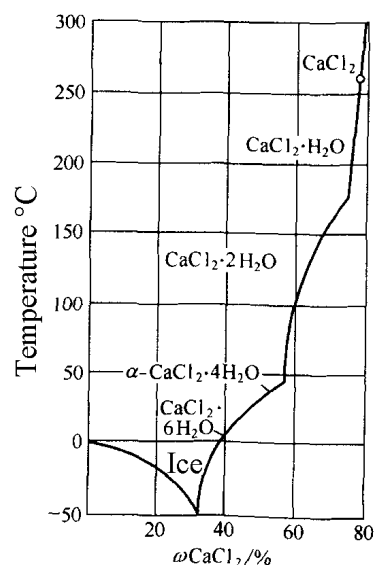
According to the current enterprise standard, the quality indexes of calcium chloride (dihydrate) are: $\text{CaCl}_2 \geq 70\%$, $\text{NaCl} \leq 2.5\%$. The quality indexes of refined salt: $\text{NaCl} \geq 99\%$, $\text{Ca}^{2+} \leq 0.8\%$, $\text{SO}_4^{2-} \leq 0.02\%$, water insoluble $\leq 0.03\%$.

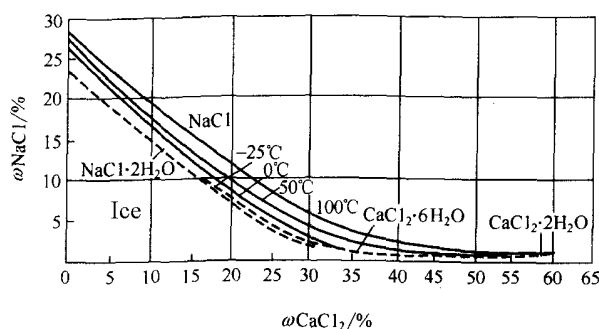
Consumption Quotas Consumption quota for per ton of calcium chloride dehydrate: waste liquor: 7.5m^3 ; steam: 3.2t; electricity: $19.3\text{kW}\cdot\text{h}$; river water: 120m^3 . Consumption quota for per ton of refined salt (1.2 t refined salt is produced from production of 1t calcium chloride dehydrate): crude salt: 0.8 - 0.85 t; steam: 2.7 t; electricity: $31.1\text{kW}\cdot\text{h}$; river water: 56m^3

3. Production Methods

Calcium chloride products in China mainly include calcium chloride dihydrate and anhydrous calcium chloride. The production methods can be divided into: ammonia alkali waste liquor recovery method, potassium chlorate waste liquor recovery method and hydrochloric acid-limestone method. Only the recovery of ammonia alkali waste liquid is described here.

(1) **Process flow and process conditions** Calcium chloride is recovered from the distillation waste liquor of ammonia alkali plants and refined salt (sodium chloride) is produced as a byproduct, which is also called salt and calcium co-production method. The process flow is shown in Figure 16-5 and Figure 16-6.

Table 16-3 Solubility of CaCl_2 - H_2O System

Fig. 16-4 Co-solubility of NaCl and CaCl₂ in waterTable 16-5 Solubility of NaCl-CaCl₂-H₂O System

$t/^{\circ}\text{C}$	Liquid phase		Solid phase	$t/^{\circ}\text{C}$	Liquid phase		Solid phase
	$\omega\text{NaCl}/\%$	$\omega\text{CaCl}_2/\%$			$\omega\text{NaCl}/\%$	$\omega\text{CaCl}_2/\%$	
-25	13.8	11.2	NaCl · 2H ₂ O + ice	75	27.45	0	NaCl
	7.4	20.0	NaCl · 2H ₂ O		1.7	40.0	NaCl
	1.3	32.8	NaCl · 2H ₂ O + CaCl ₂ · 6H ₂ O		1.0	50.0	NaCl
	0	33.5	CaCl ₂ · 6H ₂ O		0.9	55.0	NaCl
0	26.3	0	NaCl	100	0.8	58.4	NaCl + CaCl ₂ · 2H ₂ O
	8.4	20.0	NaCl		0	58.8	CaCl ₂ · 2H ₂ O
	0.9	35.0	NaCl		28.2	0	NaCl
	0.6	36.9	NaCl + CaCl ₂ · 6H ₂ O		11.4	20.0	NaCl
25	0	37.2	CaCl ₂ · 6H ₂ O	125	2.2	40.0	NaCl
	26.45	0	NaCl		1.2	55.0	NaCl
	8.9	20.0	NaCl		1.1	60.2	NaCl + CaCl ₂ · 2H ₂ O
	0.7	40.0	NaCl		0	60.9	CaCl ₂ · 2H ₂ O
50	0.5	44.65	NaCl + CaCl ₂ · 6H ₂ O	125	29.0	0	NaCl
	0	44.9	CaCl ₂ · 6H ₂ O		12.3	20.0	NaCl
	26.8	0	NaCl		2.9	40.0	NaCl
	9.6	20.0	NaCl		1.7	55.0	NaCl
	0.6	55.0	NaCl		1.6	60.0	NaCl
	0.6	56.6	NaCl + CaCl ₂ · 2H ₂ O		1.5	62.8	NaCl + CaCl ₂ · 2H ₂ O
	0	56.9	CaCl ₂ · 2H ₂ O		0	63.8	CaCl ₂ · 2H ₂ O

The technological process is characterized by fully removing calcium (CaCl₂) in salt making and fully removing salt during calcium chloride making to ensure the quality of both products.

The distillation waste liquor is naturally evaporated on the beach to concentrate to contain 120 g/L CaCl₂, sent into a salt dissolving barrel, and added with some crude salt to make a calcium brine containing 90 g/L CaCl₂ and 220g/L NaCl. After being preheated by a preheater, the calcium brine is sent to a double-effect evaporator for counter-current evaporation, so as to prepare refined salt and calcium chloride solution. The calcium chloride solution is then made into a calcium chloride dihydrate product via a climbing film device and a falling-film device.

The technological conditions of double-effect evaporation for refined salt production are as follows: the first-effect temperature is 125°C, the evaporator pressure is $(0.196 - 0.392) \times 10^5 \text{ Pa}$, and the heating steam pressure is $(4.9 - 5.39) \times 10^5 \text{ Pa}$; the secondary effect temperature is 74°C, and the evaporator pressure is $0.80 \times 10^5 \text{ Pa}$. The two-effect temperature is 74°C and the evaporator pressure is $0.80 \times 10^5 \text{ Pa}$.

After double-effect evaporation, the calcium brine was concentrated to contain 450 g/L CaCl₂; at the same time, the NaCl crystals are precipitated, and the calcium brine is then sent to a salt slurry barrel, and further to a centrifuge for separation; sodium carbonate solution is sprayed to prevent agglomeration; then, the solution is dried in a fluidized bed furnace to obtain a high-quality refined salt containing 99.0% -99.6% NaCl.

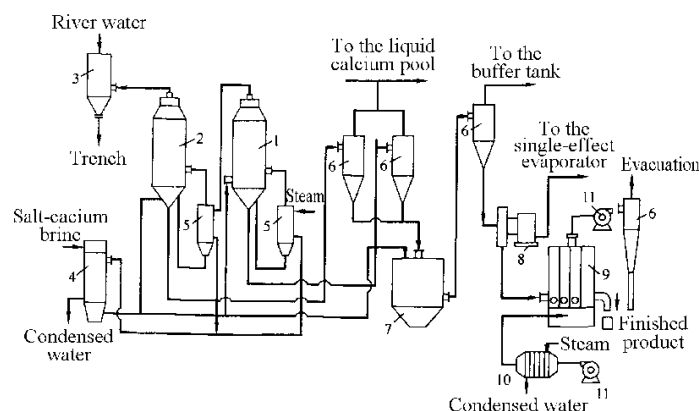


FIG. 16-5 Refined Salt Production Flow

1-One-effect evaporation tank; 2-Two-effect evaporation tank; 3-Water ejector; 4-Preheater; 5-Heater; 6-Separator; 7-Salt slurry tank; 8-Centrifuge; 9-Fluidized bed drying furnace; 10-Preheater; 11-Air blower;

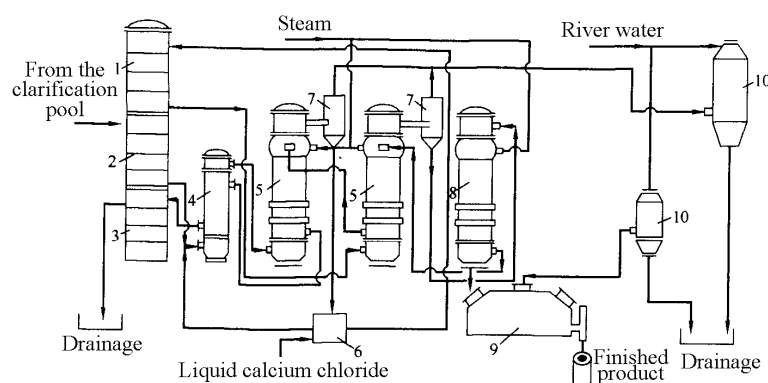


FIG. 16-6 Process Flow for Liquid Calcium Chloride Production

1-Calcium liquid tank; 2-High brine tank; 3-Hot water tank; 4-Preheater; 5-Climbing film evaporator; 6-Liquid calcium pool; 7-Separator; 8-Falling film evaporator; 9-Storage tank; 10-Water ejector

The technological conditions for calcium chloride production by film evaporation method are as follows: the calcium brine concentrated by the double-effect evaporator is clarified for salt precipitation; the precipitated salt having a high CaCl_2 content is sent back, as a raw material salt, to the salt dissolving barrel for reuse; the clarified calcium solution is concentrated to contain 600g/LCaCl_2 by a climbing-film evaporator; after clarifying and removing NaCl , the solution is sent to a falling-film evaporator to be evaporated to contain 70% - 72% CaCl_2 ; then the product is packed with barrel, which becomes a solid calcium chloride dihydrate product when becoming cooled.

In addition to barreled calcium chloride dihydrate, it can also produce flaky calcium chloride dihydrate products. The process for producing flaky calcium chloride dihydrate product is: the solution evaporated by a falling film evaporator to contain 70% - 72% liquid calcium chloride is put into a storage tank that is thermally insulated with steam, and flows by gravity into a drum-type flaking machine; the inner surface of the drum is sprayed with cooling water, so that the liquid calcium chloride on the outer surface of the drum solidifies into solid calcium fluoride with a thickness of 1 - 2mm, which is scrapped by a scraper as flaky calcium chloride; the flaky calcium chloride is cooled to 60-70°C and packed in polyethylene woven bags (a new film is sandwiched between two layers of woven bags).

In preparing high-quality CaCl_2 , impurities should be further removed during clarification. The method comprises the following steps: removing NaCl from the waste CaCl_2 solution evaporated to 40% concentration,

Attachment 4B

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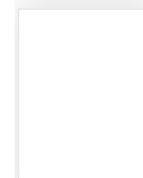
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