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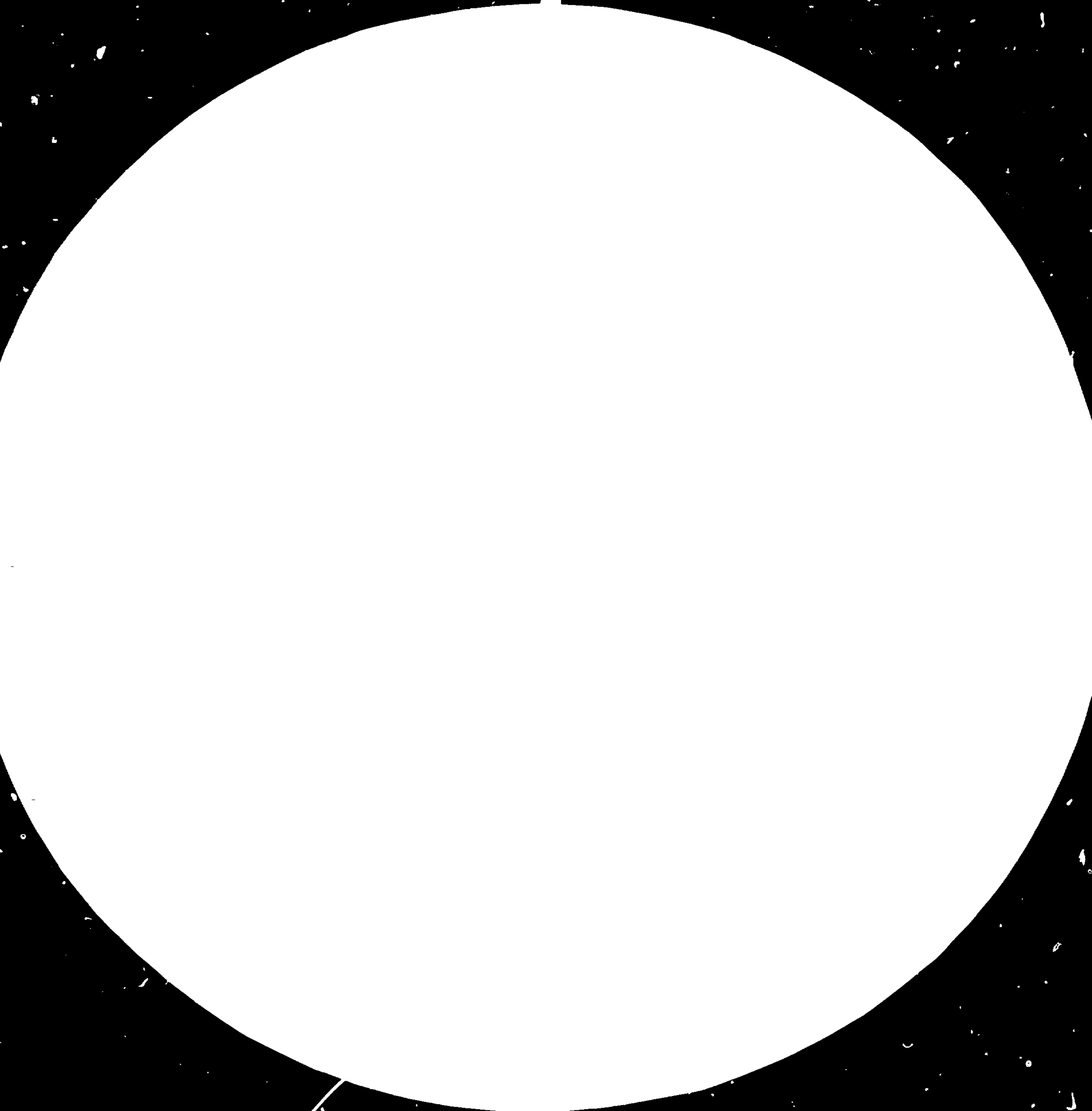

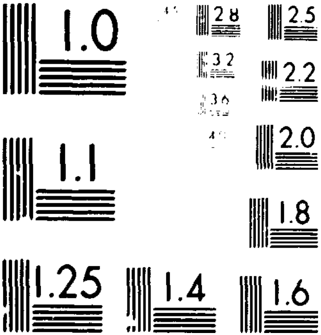

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AMMONIA PLANT SAFETY

A REVIEW OF THE SILVER ANNIVERSARY SYMPOSIUM ON SAFETY IN AMMONIA PLANTS AND RELATED FACILITIES *

by

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A milestone of sorts was reached this year when the 25th annual symposium was held in Portland, Oregon. Over 400 were in attendance from all over the world representing 26 different countries.

It is a tribute to the American Institute of Chemical Engineers which provide the forum that these meetings are held at all. For it was a small group of men attending an AIChE meeting in Boston in 1955 that organized the group which became known as the "Ammonia Plant Safety Committee." These men conceived the idea that lives could be saved through a discussion and meeting of the minds in the, then, rapidly expanding nitrogen industry. Several severe injuries and fatalities occurred as those involved in the building and operation of these plants had little, or no experience with high pressure gas systems and new cryogenic air separation plants. Several plants had experienced severe explosions and some papers were given on the subject at that autumn AIChE meeting in Boston.(1) From this beginning came the programs that we are reviewing today, and thus the preamble for this years meeting:

> "The annual symposium is a forum where those involved with manufacture, storage, and transportation of ammonia can meet to share knowledge, experience and new technology related to safe and efficient operation. It provides the vehicle for communication between contractor, operator, and engineer to talk not only about their successes but also about their failures."

Safety is everyone's responsibility: the designers, the engineers, and the operators. It requires team work, it requires constant communication between them, and it requires constant study and review. For it is not just the new plants who experience accidents, but the old plants as well, and well run plants with envious records, as born out by the papers presented at this year's symposium.

The papers presented this year point out (1) the importance of team work between designer and operator through conception, startup and operation, (2) the importance of operator training and a program of continual review, and (3) the importance of good, well-planned preventive maintenance programs.

In a urea plant built in 1970, a leak developed in the oil sump of the ammonia receiver in 1979. The receiver had been inspected in 1976 and was in satisfactory condition. The plant was shut down and the receiver given a thorough inspection. About 300 cracks were found, all originating from weld areas. In checking the original construction prints of the vessel, it was discovered that the vessel had not been stress relieved. From operating conditions and materials of construction, ie, dry ammonia with trace amounts of oxygen and medium strength normalized steel that was not stress relieved, stress corrosion cracking was deemed the cause. The cracks were repaired, the vessel hydrotested, stress relieved, and returned to service.[2]

The consequences of relying on only one point or piece of information in making decisions involving plant operations, the importance of operator training, and a continual review of emergency procedures and trip systems was pointed out in the paper by Ezzat Hasaballah. Through inadvertant actions during an emergency causing a total plant shutdown and subsequent startup, 159 reformer tubes were damaged, requiring the unit to be down 55 days for repair. Most of the tube damage was due to firing the furnace for about five minutes after flow dropped off through the tubes. Trips had been bypassed during the initial plant startup because of several false shutdowns and never activated, but were needed six years later during the emergency. Additionally the emergency occurred right at shift change. Fires were relit, and no indication of the damage noted until process gas was introduced into the tubes and fire was seen from the burner air registers and furnace inspection doors. Furnace firing had continued even though the outlet header thermocouples did not show any rise in temperature after steam flow to the furnace had been established.

In another incident at this plant, it was decided to oxidize the high temperature shift catalyst out of service prior to vessel entry. All of the precautions to monitor the operation and insure its success had been set up, ie, monitor bed temperatures for temperature rise and analyze the outlet mixture for oxygen depletion and at the end, for the same oxygen content in and out. Everything proceeded according to plan, except that the people actually following the operation elected to not monitor the oxygen and rely solely on catalyst bed temperatures. When the thermocouples indicated completion, a large amount of air was introduced when actually there was still some three to four feet of catalyst not oxidized. The reactor shell was overheated to the extent that it had to be discarded.(3)

In the design of a new plant or in modifying existing plants, it is always well to review each part in detail, follow the flow of each stream through each line and play the "what if" game, ie, what if this valve fails, what if this flow stops, what if ---, what if ---. Then during construction follow out each line, each support, etc.

The question should be asked, "Is someone backing up far enough, far enough from the immediate problem at hand to see the total picture?" For many times, a group will be so intent on fixing the immediate problem that a real solution to the problem is possibly overlooked.

Such could be the case as described in papers presented by George Connaughton and H. G. Orbons.

As pointed out by Mr. Connaughton, poor communications and followup between contractor, designer, and operator contributed to the superheater steam outlet header failure within a year after startup. After discovery of the initial problem, ie, growth in the wrong direction, it was found that the stops were incorrectly installed.[5]

In describing the events leading up to the catastrophic failure of the reformer exit line, Mr. Orbons noted that the rupture occurred a full seven minutes after the emergency trip killed the fires in the reformer. The addition of a desulfurizer unit to the original plant design increased, the volume of the feed gas line to the plant, and as a consequence, the time needed to purge downstream of the emergency stop valve.[18]

Several papers were presented which discussed new techniques and systems in setting up preventive maintenance programs. A new system for non-destructive testing and evaluation of ferrous tubular materials was described by Bill Holloway of ITC Corporation in Baton Rouge, Louisiana. The test system is called the Magnetic Tube Analyzer (MTA). Accomplishments have been achieved in the testing of various ferromagnetic tube materials such as carbon steel, chrome-molybdenum, 2-6% (Ebrite), nickel, Monel, Carpenter 7 MO, and bio metals. Various modes of failure, such as holes, pits, cracks, corrosion-erosion, and wall loss have been detected. Certain limitations and precautions must be noted however, when testing for certain modes of failure. Tests can be performed on tubes with ID's ranging from one-half inch to two and one-fourth inches, but there is a limit to the maximum wall thickness which can be approximated by taking one-ninth of the outside diameter. Also the internal probe to inside diameter of the tube must fit fairly tightly. Thus, the tubes must be clean from I.D. deposits before inspecting.[27]

The use of modern day electronics in diagnosing rotating machinery problems was presented in papers by Larry Fisher, John Sohre, and Paul Nippes.

Both preventive and predictive maintenance programs have been set up at IMC's Sterlington, Louisiana complex. Preventive maintenance involves (1) established routes directing personnel to each piece of equipment, the type of lubricant, and method of application, (2) lube sampling program on all major lube oil consoles, (3) purification and filtration program and (4) open and inspect schedules based on operating history. Predictive maintenance is divided into three categories; (1) Equipment under 400 horsepower, (2) Equipment over 400 horsepower, and (3) Reciprocating compressors. On equipment under 400 horsepower, a portable spectrum analyzer is used, data is recorded on a routine basis, and a new signature line is established after each overhaul. A different approach is taken on large machinery, primarily in data gathering and recording. All of the equipment has permanently installed, non-contacting probe transducer systems to monitor shaft displacement radially in both horizontal and vertical planes, and axially. Almost all journal and thrust bearings have installed RTD's (Resistance Temperature Device) for continuous monitoring of actual bearing temperatures. Gear units have permanently installed accelerometers for continuous monitoring and recording of gear mesh frequencies. All of these imputs are hard wired to a control room for monitoring and recording of data. Routine data is stored automatically every two hours as well as instantaneous data if certain set limits are exceeded. From this, trends are developed for predictive maintenance work. Bearing inspection is 100% dependent upon trend analysis. For example, if radial vibration levels exceed 1 mil peak to peak for an extended time, bearing inspection would be scheduled at the next available turnaround.(25)

Mr. Sohre and Mr. Nippes presented an update on electromagnetic shaft currents in large turbomachinery. While the phenomenon of electromagnetic shaft current generation has been understood for a long time, designers and operators were generally not aware of the problem. These men discussed the present state of the art in brush design and installation, measurement techniques, and methods of demagnetizing turbines, compressors and other machinery lineups. It was pointed out that to be completely successful, the units must be completely disassembled, the rotors must be removed to demagnetize the case, etc. The importance of recognizing this phenomenon is pointed out by the fact that in the last month, one Gulf Coast plant experienced three failures, two of which have been identified as caused by electromagnetism. Welding on the equipment; legs, support repair, etc., is now known to cause electromagnetism, and was done during a recent turnaround. It is beyond the scope of this paper to go into this subject in detail, as whole seminars have been devoted to it. But the names and addresses of Mr. Sohre and Mr. Nippes are included in the references should you desire more information on this subject.(28)

One section of papers dealt with the ever increasing problem in the United States of rail transportation accidents.

Mr. Frank Heller of Phillips Petroleum Company gave a very comprehensive review of the factors involved in setting up a tank car loading procedure. However, it lends itself to all kinds of transportation.[21]

Of major significance was the discussion of a recent accident at Agrico Chemical Company's Oklahoma plant, where a 30,000 gallon tank car being loaded with anhydrous ammonia failed catastrophically, killing the two loaders. While the investigation is not complete, [22] the incident is similar to other recent failures which were reviewed by Bob Eiber of Battelle Columbus Laboratories. A number of delayed failures associated with mechanical damage have occurred recently. They have been traced to starting at a weld seam where a small crease or burn crossed the weld area.[23]

The discussion pointed out the caution and care to be exercised in handling loaded rail cars, at the scene of the accident, and later in the plant. At the scene, a non-leaking car will normally be set aside for handling later. These cars should not be ignored, but should be inspected closely for any creases or burns. While each case must be handled on its own merits, discussion from the floor led to the conclusion that one of the first considerations should be to reduce the pressure in the tank as soon as possible to relieve stress on the weld area. This will buy time while the rest of the plan is formulated and put into motion.

As a result of their incident, Agrico has developed a rather extensive and detailed inspection procedure to be followed before any car is loaded.[22] Since the symposium, other companies have reported finding similar imperfections on their cars brought in for loading. Hopefully, other accidents about to happen, have been averted by the sharing of this incident with the industry.

Other papers presented dealt with energy savings through various means; the operation of hydrogen recovery units, the operating experience of newly designed heat recovery units, considerations for maintaining reliability while reducing energy consumption, and the use of new micro computers in off-line evaluation of ammonia plant operations.

A complete list of the papers presented has been included in the reference section. The proceedings, including the papers and the discussion comments, will be published by the American Institute of Chemical Engineers as "Volume 22, Ammonia Plant Safety" and will be available about mid-year, 1981.

The twenty-sixth symposium will be held in conjunction with the "Second World Congress of Chemical Engineering and World Chemical Exposition" in Montreal, Canada, October 4-9, 1981.

PAPERS PRESENTED AT THE 1980 SYMPOSIUM
SAFETY IN AMMONIA PLANTS AND RELATED FACILITIES

(1) "The Last Twenty-Five Years" by John A. Lawrence, C. F. Industries, Inc., Long Grove, Illinois.

(2) "Inspection and Repair of an Ammonia Receiver and A Urea Reactor in a 750 T/D Urea Unit" by P. C. Campbell and Howard E. Dunifon, Vistron Corporation, Lima, Ohio.

(3) "Two Problems Causing Metal Overheating and Equipment Failure" by Ezzat M. Hazaballah, Petrochemical Industries Company, Kuwait.

(4) "The Tale of the Run Away Methanator" by A. J. M. Janssen and J. M. Blanken, UKF, Ijmuiden, Holland.

(5) "Failure of 1500 psi Superheated Steam Header" by George E. Connaughton, Columbia Nitrogen Corp., Augusta, Georgia.

(6) "Steam Load Balancing in a Fertilizer Complex" by D. R. Philip, CIL, Inc., Sarnia, Ontario, Canada.

(7) "Improving Efficiency in an 1150 T/D NH_3 Plant" by Glenn A. Combs, International Minerals & Chemical Corp., Sterlington, Louisiana.

(8) "Purge Gas Purification and Recovery in NH_3 Plants" by R. Harmon, Agrico Chemical Company, Verdigris, Oklahoma and W. H. Isalski, Petrocarbon Developments, Ltd., Manchester, England.

(9) "Spherical Shaped NH_3 Synthesis Catalyst for Low Energy NH_3 Production" by U. Zardi and E. Comandini, Ammonia Casale S.A., Lugano, Switzerland.

(10) "Horizontal Fire Tube Waste Heat Boilers in NH_3 Plants" by Dipl. Ing. Helmut Lachmann, Borsig GMBH, Postfach, Berlin Germany.

(11) "Maintain Reliability While Reducing Energy Consumption in Modern Day NH_3 Plants" by Jerry L. Lewis, Fluor Engineers & Constructors, Inc., Irvine, California.

(12) "TVA NH_3 From Coal Project - An Update" by Robert A. Moon, Brown & Root, Inc., Houston, Texas.

(13) "Status - Coal to NH_3" by L. J. Buividas, Pullman Kellogg, Houston, Texas.

(14) "The Application of Special High Pressure Steam Equipment in a Low Energy NH_3 Plant" by Heinz Graeve, UHDE GMBH, Dortmund, West Germany.

(15) "Efficient Operation of NH_3 Plants at Reduced Rates" by John C. Stover, Cooperative Farm Chemicals Association, Lawrence, Kansas and Robert E. Poore, Farmland Industries, Enid, Oklahoma.

(16) "Stress Corrosion Crackings of Heat Resisting Alloys for Steam Reformer Plants" by K. Takemura, T. Shibasaki, and T. Kawai, Chiyoda Chemical Engineering & Construction Co., Ltd., Kawasaki, Japan.

(17) "Use of Micro Computers in Off-Line Evaluation of NH_3 Plant Operations" by R. W. Parrish, Parrish and Associates, Inc., Boulder, Colorado.

(18) "The Little Leak That Caused A Big Leak" by J. O. Oosterling and H. G. Orbons, U.K.F., Geleen, Holland.

(19) "Transfer Line Failure in Chevron's 1500 T/D NH_3 Plant" by R. G. Lueders, Chevron, USA, Inc., Pascagoula, Mississippi.

(20) "Refrigerated Storage Tank Retainment Walls" by Jos Aarts and D. V. Morrison, Chicago Bridge & Iron Company, Oak Brook, Illinois.

(21) "Ammonia Tank Car Safety" by Frank J. Heller, Phillips Petroleum Company, Bartlesville, Oklahoma.

(22) "Rupture of an Anhydrous Ammonia Rail Car" by T. F. Tandy, Agrico Chemical Company, Catoosa, Oklahoma.

(23) "A Review of Some Tank Car Failures - What Are They Telling Us?" by R. J. Eiber, Battelle Columbus Laboratories, Columbus, Ohio.

(24) "A Working Preventive Maintenance and Inspection Program" by F. J. Chandler and J. B. Brooks, Agrico Chemical Company, Donaldsonville, Louisiana.

(25) "Vibration Monitoring Diagnostics as a Predictive Maintenance Tool" by Larry Fisher, International Minerals & Chemical Corp., Sterlington, La.

(26) "Mixed Feed and Secondary Air Line Failures Averted" by William E. Ellis, E. I. du Pont de Nemours Co., Inc., Wilmington, Delaware.

(27) "Eddy Current Inspection of Ferrous Tubular Material and Reformer Catalyst Tubes" by L. W. Holloway, R. F. Bauer, T. D. Pittman, Industrial Technical Corp., Baton Rouge, Louisiana.

(28) "An Update on Electromagnetic Shaft Current Problems in Large Turbomachinery" by John S. Sohre, Consultant, Ware, Massachusetts and Paul I. Nippes, Nippes Professional Association, Woodbridge, New Jersey.

(29) "Catalysts, A Recipe for Longer Life" by Dr. J. G. Livingstone and J. D. Rankin, Imperial Chemicals Industries, Inc., Billingham, England.