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Vol. 1

Rupture of Model 48Y UF_6 Cylinder and Release of Uranium Hexafluoride

Sequoyah Fuels Facility
Gore, Oklahoma
January 4, 1986

U.S. Nuclear Regulatory Commission

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Augmented Investigation Team

U.S. Nuclear Regulatory Commission
Uranium Recovery Field Office
Region IV
Denver, CO 80225

ABSTRACT

At 11:30 a.m. on January 4, 1986, a Model 48Y UF_6 cylinder filled with uranium hexafluoride (UF_6) ruptured while it was being heated in a steam chest at the Sequoyah Fuels Conversion Facility near Gore, Oklahoma. One worker died because he inhaled hydrogen fluoride fumes, a reaction product of UF_6 and airborne moisture. Several other workers were injured by the fumes, but none seriously. Much of the facility complex and some offsite areas to the south were contaminated with hydrogen fluoride and a second reaction product, uranyl fluoride. The interval of release was approximately 40 minutes.

The cylinder, which had been overfilled, ruptured while it was being heated because of the expansion of UF_6 as it changed from the solid to the liquid phase. The maximum safe capacity for the cylinder is 27,560 pounds of product. Evidence indicates that it was filled with an amount exceeding this limit.

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PREFACE

The U.S. Nuclear Regulatory Commission Augmented Investigation Team, which conducted the investigation of the accident at the Sequoyah Fuels Conversion Facility, consisted of the following members:

R. Dale Smith, Leader
Charles Cain
Ross Chappell

Serving as special advisors were:

J. O. Dodson, Oak Ridge Gaseous Diffusion Plant
Martin Schwartz, Lawrence Livermore National Laboratory
Otto Warnlof, National Bureau of Standards
Jackie Bess, U. S. Nuclear Regulatory Commission, Region IV

ACKNOWLEDGMENTS

The Augmented Investigation Team wishes to acknowledge the patience, courtesy, and cooperation shown by the employees of Sequoyah Fuels Corporation during their interviews with the team members. During this stressful time, these people were most helpful in providing the team with valuable information and insight.

EXECUTIVE SUMMARY

Accident Summary

At 11:30 a.m. on January 4, 1986, a Model 48Y UF_6 cylinder filled with uranium hexafluoride (UF_6) ruptured while it was being heated in a steam chest at the Sequoyah Fuels Corporation's Sequoyah Facility near Gore, Oklahoma. One worker died because he inhaled hydrogen fluoride fumes, a reaction product of UF_6 and airborne moisture. Several other workers were injured by the fumes, but none seriously. Much of the facility complex and some offsite areas to the south were contaminated with hydrogen fluoride and a second reaction product, uranyl fluoride (UO_2F_2). The interval of release was approximately 40 minutes.

The cylinder, which had been overfilled, ruptured while it was being heated because of the expansion of UF_6 as it changed from the solid to the liquid phase. The maximum safe capacity for the cylinder is 27,560 pounds of product. Evidence indicates that it was filled with an amount exceeding this limit.

Conduct of the Onsite Investigation

An Augmented Investigation Team (AIT) was formed by U.S. Nuclear Regulatory Commission (NRC) Region IV to conduct an investigation into the facts surrounding the incident. The objectives of the AIT's investigation were to determine the facts surrounding the incident; to identify any generic and specific safety concerns related to the incident and to document its findings and conclusions. The team consisted of personnel from Region IV and NRC Office of Nuclear Material Safety and Safeguards and was supplemented by technical experts from Oak Ridge Gaseous Diffusion Plant, Lawrence Livermore National Laboratory, National Bureau of Standards, and NRC. The first team members were on site the evening of January 4, the day of the incident. The AIT began interviews with key employees of Sequoyah Fuels Corporation on January 6. These interviews, which were transcribed, provide much of the basis for the findings of the investigation and the conclusions drawn.

In addition, the AIT conducted or participated in several special studies that contributed to its findings. Samples were taken of the residual contents of the cylinder for analysis. These samples showed that no unusual materials were present. An examination of the process instrumentation was conducted. Process instrumentation failure was not a contributing factor. An examination and test was made of the scales used for filling cylinders and the scales used for final weighing of the product. No abnormalities were found and the scales were judged to perform within expected tolerances. A detailed metallurgical examination of the failed cylinder is under way. Results of this examination will be issued at a later date. A draindown of the process equipment is planned to provide an independent estimate, on a by-difference basis, of the amount of material that was in the cylinder that failed.

Facts Surrounding the Incident

The Sequoyah facility is one of two facilities in the United States that convert uranium oxide concentrates received from mining and milling operations to uranium hexafluoride (UF_6). The UF_6 product is shipped to enrichment facilities located in the United States and abroad. The plant is located in eastern Oklahoma, approximately 25 miles south of Muskogee.

The UF_6 is created at a high temperature as a gas. The gas is collected in cold traps where the reduced temperature causes the material to collect as a solid. When a sufficient amount of solid is collected, the traps are heated and the liquefied UF_6 is drained by gravity into cylinders that serve as storage, shipping, and process containers. The amount of material introduced into a cylinder is measured by observing the weight gain of the cylinder while it is on a set of scales during the filling process.

It has been determined, through interviews and observations, that the cylinder that ultimately ruptured was not properly placed on the scales during its filling. This was due, in large measure, to the fact that the 14-ton cylinder being filled was longer than the 10-ton cylinder for which the equipment was originally designed. This caused the cart on which the cylinder rested to be positioned very close to the edge of the scale platform. Because of the misalignment of the cylinder and the cart, one wheel of the cart supporting the affected cylinder was off the platform and was resting on the floor. This caused erroneously low readings on the scale during filling.

When the operator noted that he was unable to add more UF_6 to the cylinder, he investigated and discovered that the wheel was off the platform. After the cart and cylinder were repositioned, the scale was unable to record the actual weight of the cylinder because the weight exceeded the dial indicator range. The cylinder at this point weighed more than 29,500 pounds, the limit of the dial indicator. Later estimates place the weight in excess of 31,000 pounds. The fill specification for this cylinder is 27,560 pounds. The operator adjusted the tare-compensating mechanism on the scale to permit observation of weight loss while he attempted to evacuate the excess material by vacuum back into the cold traps. This evacuation attempt is in accordance with procedures and accepted practice.

On the subsequent shift, the next operator concluded that the material was no longer being evacuated, presumably because the contents of the cylinder had cooled and solidified. The operator and the assistant shift supervisor moved the cylinder to a steam chest for the purpose of heating the cylinder to liquefy the contents and facilitate later evacuation. The weight of the contents at this point is not known, but the cylinder definitely contained more than the fill specification of 27,560 pounds. In any case, the cylinder was definitely overfilled. Sequoyah Fuels Corporation operating procedures prohibit the heating of an overfilled cylinder. Placing the overfilled cylinder in the steam chest for heating was clearly a violation of these procedures.

Approximately 2 hours after heating began, the cylinder ruptured in the steam chest. A 4-foot lengthwise rupture occurred along the top of the cylinder.

The force of the explosion damaged the steam chest enclosure. The escaping UF_6 rapidly reacted with moisture in the air to form uranyl fluoride and hydrofluoric acid. The resulting vapor cloud of these materials was carried south by southeast by a wind gusting to 25 mph. The cloud enveloped the process building, and the acidic vapor caused the death of an operator who was working approximately 70 feet from the cylinder. The vapor was drawn into the plant ventilation system. Approximately 40 workers in the building evacuated to an upwind location on site, some passing through the cloud.

Notification of NRC and civil authorities is estimated to have begun within 10 minutes. The injured workers were transported by fellow workers to nearby hospitals for treatment. The general population downwind was contacted and advised to evacuate and report to hospitals for examination. A physician arrived on site shortly after the accident and examined and released site workers. Various local, state, and federal officials were notified by the licensee from the corporate office in Oklahoma City. Residents downwind of the site were contacted by licensee employees and advised to proceed to a local hospital. The general public was notified by local radio.

Meanwhile, at the site of the ruptured cylinder, plant personnel manned water hoses with fog nozzles in an attempt to suppress further airborne release of material.

Within an hour and a half, radiological surveys began both on and off the site. State, federal, and company officials arrived at the site during the ensuing hours, and recovery operations began.

As a result of its preliminary investigation at the site immediately after the incident, the Augmented Investigation Team concluded that the cylinder was not defective but failed because of stress caused by hydraulic pressure that resulted from the expansion of the UF_6 in the cylinder when it was heated. The UF_6 undergoes an increase in volume of about 36% when it changes from solid to liquid form at its melting point of 147°F. It continues to expand further (~0.1% per °F) when heated above its melting point. Large internal pressures can be produced hydraulically when liquid contents expand to a volume greater than the volume of the vessel in which they are contained.

Factors Contributing to the Cause of the Accident

The following factors were identified as the primary contributors to the accident. They are arranged chronologically, in the order in which they occurred. No attempt has been made to rank them according to importance.

(1) The cylinder was overfilled because it was not placed fully on the scales.

The fill bay and associated equipment were not designed to prevent improper positioning of cylinders in the bay so that the cylinder would not be on the scales.

The fill bay was not designed to accommodate 14-ton cylinders.

(2) The time required for filling the cylinder was long enough to allow partial solidification of the UF_6 which inhibited product removal from the cylinder.

(3) The precise weight of the cylinder was not readily determinable after it was overfilled.

(4) There was no secondary or alternate way to measure the quantity of material in a cylinder being filled.

(5) Employees violated company procedures when they heated an overfilled cylinder.

Workers, including line management personnel, had not been trained in regard to company procedures.

Procedural controls such as checklists or approval points were not an integral part of plant operations.

(6) Equipment for monitoring or automatically venting cylinders that are being treated was not provided for by the plant design.

In summary, the factors can be aggregated into the following causes of the accident:

- The physical equipment and facilities used for filling and weighing UF_6 cylinders were inappropriate for safe use with 14-ton cylinders.
- The training of workers in operating procedures and ensuring the implementation of these procedures were not carried out effectively.

1 INTRODUCTION

This investigation was conducted in accordance with the draft Procedure for Augmented Investigation Team (AIT) Response to Operational Events. Accordingly, the objectives of the investigation were

- to conduct an onsite fact-finding investigation of the January 4, 1986, accident
- to determine the facts surrounding the event investigated
- to identify and communicate any generic and specific safety concerns related to this event
- to document the findings and conclusions of the onsite investigation

Furthermore, the scope of this investigation <u>did</u> <u>not</u> include

- an examination of proposed licensee (Sequoyah Fuels Corporation) actions to correct the cause of the event
- licensee actions taken or planned to be taken before resumption (or continuation) of plant operation
- recommendations for enforcement actions by the NRC
- evaluation of the adequacy of the NRC's or other Federal agency's response to the incident

Actions continue concerning this accident. This AIT Report, when combined with reports of other actions, will present a more complete view of the causes of the accidents, its consequences, and corrective actions necessary.

2 CONDUCT OF THE ONSITE INVESTIGATION

2.1 Personal Interviews

Over a 3-day period shortly following the accident (January 6-8, 1986), members of the Augmented Investigation Team conducted personal interviews with Sequoyah Fuels Corporation employees who had first-hand knowledge of the events leading up to, during, and immediately following the incident. Fifteen employees were interviewed during this period. In a second series of interviews, held on January 27 and 28, questions focused on the employees' state of training, the program for training employees, the general knowledge and use of written procedures, and the extent of heating overfilled containers. Over the course of the investigation, 33 interviews were conducted and involved 24 employees.

All of the interviews were recorded by a stenographer and transcripts were prepared. A copy of the transcripts is being placed in the PDR.

The results of the interviews are not reported separately; rather, they form much of the basis for the observations and descriptions contained in the investigation team's report.

2.2 Cylinder Contents

On Friday, January 10, a crew of Sequoyah Fuels Corporation employees removed a temporary plug of rags from the ruptured cylinder so that the residual contents could be examined and the cylinder prepared for safe storage pending metallurgical testing.

The crew found a small amount of yellowish, sludge-like residue in the cylinder. Samples were taken of this material. When water was applied to the interior of the cylinder to wash out the residue, whitish vapors were generated, presumably hydrogen fluoride. These vapors were suppressed by means of fire hoses with fog nozzles spraying large amounts of water over the cylinder. The rinse water from the cylinder was sampled during the cleaning process. In all, six samples of sludge and rinse water were collected.

Each of the samples was split; half was retained by Sequoyah Fuels Corporation and half was being given to the NRC staff. The NRC samples were sent to Oak Ridge National Laboratory where they were analyzed at the K-25 laboratories. The results of these analyses do not indicate any significant presence of carbon. Only hydrogen fluoride and uranium compounds were reported. Carbon residues would indicate the presence of some organic or carbonaceous material that might have contributed to the rupture. Since less than 0.1% carbon was measured in the residue, one can conclude that such a foreign material was not present.

2.3 Scale Testing

On January 28 and 29, an examination was made of the south scale of the two in the UF_6 drain station and the scale in the final product weigh station.

The Sequoyah Fuels Company submitted a preliminary plan for testing to the NRC staff for approval. After some minor adjustments to the plan, the NRC staff gave its approval and the testing was scheduled. Participating in the testing were the National Service Manager for Streeter-Richardson, the scale manufacturer; a representative of the National Bureau of Standards, who acted as technical observer for the NRC; four representatives of the Oklahoma Division of Weights and Measures who furnished known weights for the test; two technicians from the Oklahoma Scale Company, who were available to make any needed repairs; the Manager of the Sequoyah facility, who represented Sequoyah Fuels Corporation; and the Director of the Uranium Recovery Field Office, NRC, who represented the Augmented Investigation Team for the NRC.

The south drain station scale (the one involved in the incident) was tested by applying known weights incrementally to different areas of the scale platform. Because the scale has an uncalibrated tare-compensating beam, the zero setting for the beam was first determined through the use of known weights. When this zero setting was determined, additional weights were added and the dial indicator readings were observed. Weights were added until the capacity of the dial indicator was exceeded.

As a part of the testing, the scale mechanism was inspected, and its functioning was observed during the weighings.

In addition, the tare-compensating beam weight was placed at several positions to determine the calibration of the beam.

The conclusions of the testing of the south drain station scale were

(1) The scale was in good mechanical condition, although a number of items were identified for correction at the next routine maintenance. There were no malfunctions that would significantly affect the accuracy of the scale. Small weighing errors (30-60 pounds) could result from the fill line being connected during weighing or if the cylinder is touching adjacent piping.

(2) The environmental and maintenance conditions noted could result in weighing errors. The weighing errors would probably range from 0-100 pounds.

(3) The tare beam has a linear response to the movement of the tare poise, with each inch of displacement being equal to approximately 491 pounds.

(4) In the conduct of the scale testing and calibration, the investigators noted that the cart used to move cylinders on and off the scale platform apparently had been damaged in the past. As a result, the wheels at the east end of the cart were at an angle, confirming observations that only one of the wheels had hung up.

Because no mechanical abnormalities were observed at the south scale, no tests were performed on the matching north scale.

To verify the accuracy of final product measurements, a series of test weighings was performed on the beam balance scale in the final product weigh station. This scale is referred to as the "Control Scale" in Appendix A. The representatives of Streeter-Richardson and Oklahoma Scale Company did not participate in these tests.

The first series of test weighings was performed on the scale in its as-found condition. The space between the scale platform and the floor contained debris that the observers felt might have some effect on scale performance. At the conclusion of the first series of weighings, the platform was cleaned to remove the debris and a second series of weighings was made. After the weighings of known weights were completed, test weighings were made of Sequoyah's check weights. These were sealed UF_6 cylinders whose weights had previously been established by the National Bureau of Standards.

The results of the tests on the final product scale were

(1) The scale was in good operating condition, with only minor mechanical deficiencies noted, none of which had a significant effect on the scale's performance.

(2) The scale responded accurately over the range of weights observed.

(3) The debris observed around the scale platform had no effect on the scale's performance.

(4) The weight of the test cylinders used by the licensee for testing the scales were within $\pm$0.05 percent of their individual weights.

The detailed report of the tests is appended as Appendix A.

2.4 Process Instrumentation

The cold traps and steam chests were inspected to verify if a failure in a process control or instrumentation system was a contributing factor in the accident.

It appears that no instrumentation is used to monitor UF_6 in the cold traps. The instrumentation which is supplied with the system (load cells) is not used. Filling of cold traps is controlled on a time basis that is based on calculations of production rates.

There is no process control or instrumentation system associated with the steam chests. The UF_6 cylinders are heated inside the steam chests by manual control of steam essentially at atmospheric pressure.

A more detailed discussion of the NRC investigation of process and instrumentation control is appended as Appendix B.

2.5 Detailed Metallurgical Examination of Cylinder

Sequoyah Fuels Corporation selected, with NRC approval, the Battelle Columbus Laboratory to conduct detailed metallurgical examinations of the damaged cylinder. The principal investigator for Battelle met with Sequoyah personnel, NRC personnel, and NRC's consultant on January 31 to discuss the general scope and sequence of tests to be performed. Battelle prepared a detailed plan for testing which Sequoyah Fuels Corporation submitted to the NRC for approval. The plan involved field measurements of the damaged cylinder at its location at the Sequoyah facility. These field measurements were made on February 14 and 15. Following this, a section of the cylinder that encompasses the rupture was removed and sent to Battelle for more detailed examination in the laboratory. The NRC is represented during key steps in the examination by its consultant, from Lawrence Livermore National Laboratory.

Based on the field observations and a preliminary examination in the laboratory, the first findings reported are

- The fracture surface shows a stable slow crack at the start
- The butt welds on the stiffener rings do not have the fraction of full metal expected for a full penetration weld
- Ultrasonic testing detected a small crack in the cylinder wall under the distal stiffener ring at the failed butt weld
- The only evident thinning of the cylinder wall occurred in the area under fracture.

These findings are not inconsistent with the preliminary field investigation results.

A final report will be prepared and submitted. When available, the Battelle final report will be issued separately.

2.6 Draindown of Process Equipment

Three days before the accident, the cold traps had been drained completely for an accountability inventory, according to plant management. With only a short period of operation to account for, it is expected that a reasonably good estimate of UF_6 production can be made on the basis of operating conditions in the plant and a material balance can be conducted. Once process equipment UF_6 draindown is completed, and the amount on hand is subtracted from the amount estimated to have been produced, the difference will represent an estimate of the amount that was in the cylinder that ruptured.

Although this method is not precise, it is one more means to estimate the quantity of UF_6 that was in the affected cylinder.

The licensee has submitted a plan for NRC approval that outlines the steps to be taken to achieve this by-difference measurement.

3.0 FACTS SURROUNDING THE INCIDENT

3.1 Background Information

3.1.1 Facility Description

The Sequoyah facility is one of two facilities in the United States that convert uranium oxide concentrates received from milling and mining operations to uranium hexafluoride (UF_6). The UF_6, in turn, is shipped to enrichment facilities located in the United States and abroad. Uranium concentrates or "yellowcake" is received in powder form in 55-gallon drums or in slurry form in tank trucks. The UF_6 product is shipped from the plant primarily in 10-ton or 14-ton cylinders.

The facility began operation in 1970 with a conversion capacity of 4,550 metric tons of uranium per year. In 1978, plant expansion doubled the conversion capacity. The plant operates 24 hours per day using four rotating work shifts.

The plant is located on State Highway 10 approximately 4 miles south of Gore, Oklahoma, and 25 miles south of Muskogee, Oklahoma, at a point near the confluence of the Illinois and Arkansas Rivers. Interstate Route 40 lies 1 mile south of the plant.

Sequoyah Fuels Corporation is holder of NRC License Number SUB-1010 (Docket No. 40-8027), which was renewed on September 20, 1985. The licensee and supporting staff analysis is attached as Appendix C.

3.1.2 Management Organization

The newly appointed facility manager had only been at the site several days when the incident occurred. As indicated in the license renewal application, the various managers reporting directly to the facility manager include the Manager of Production, the Manager of Health Physics and Industrial Safety, the Manager of Conversion Engineering, the Manager of Maintenance and Construction, the Laboratory Manager, and the Manager of Industrial Relations.

The following description is depicted graphically as Figure 3.1.

Reporting to the Manager of Production are three Area Supervisors, each of whom is responsible for production activities in an assigned portion of the plant complex as follows:

(1) One Area Supervisor directs activities related to waste treatment and yellowcake sampling through a Supervisor assigned to the day shift.

(2) A second Area Supervisor directs intermediate plant processes such as solvent extraction and denitration, and supervises solid waste disposal and the plant's utilities. Each of four individuals identified as

Assistant Shift Supervisors* is assigned to one of the four rotating shifts and reports directly to the Area Supervisor.

(3) A third Area Supervisor directs final plant processes such as reduction, fluorination, and product shipping. This supervisor oversees four Shift Supervisors also assigned to the rotating shifts.

3.1.3 Process Description

The UF_6 production process is depicted in a simplified block flow diagram as Figure 3.2.

The uranium concentrate is weighed, sampled, and then digested using nitric acid to produce uranyl nitrate, which then undergoes a solvent extraction (SX) process by which impurities are removed from the product.

The impure uranyl nitrate solution enters at one end of the SX circuit, while a mixture of organic solvents that have the ability to absorb uranium enters at the other. Passing in countercurrents, the two solutions enter six stages of mixing and settling during which the uranium is extracted from the acid solution and the impurities remain in the acid.

The barren acid solution, or raffinate, is neutralized and is further processed to remove radioactive uranium daughter products, such as radium, which are stored onsite as sludge. The processed raffinate, now virtually free of radioactivity, is stored onsite in holding ponds and its volume reduced by pond evaporation. It is also used as fertilizer on property owned by the licensee.

The SX solution containing the purified uranium is re-extracted into water in a countercurrent pulse column and enters an evaporation and boil-down process. Evaporation concentrates the weak uranyl nitrate solution into molten uranyl nitrate hexahydrate (UNH). This intermediate form of uranium is subsequently converted by thermal decomposition to uranium trioxide (UO_3) in a denitration process. Electric furnaces heat the denitrator troughs, which are equipped with agitator arms that constantly stir the UNH. The UO_3 drawn from the denitrator troughs is shaped into orange-colored prills, or pellets, measuring about a millimeter in diameter. Grinding pulverizes the prills to a fine powder.

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* It should be noted that the assistant shift supervisors report administratively to the second area manager and not to the shift supervisors. However, it is informally understood, as determined through NRC interviews, that, in the case of conflict or emergency, the assigned shift supervisor is the ranking site production manager. The assistant shift supervisor serves in lieu of the shift supervisor in the latter's absence. Although there is no formal succession of authority delineated by the Sequoyah Fuels Corporation, the accepted practice is for the authority and responsibility to pass downward.

The UO_3 powder reacts with hydrogen in a two-stage, countercurrent-flow, fluid-bed reactor to produce UO_2 as a brown powder. The UO_2 powder flows into a two-stage, stirred-bed reactor with countercurrent flow. Reacting with hydrogen fluoride (HF), the UO_2 is converted to uranium tetrafluoride (UF_4), a bright green powder.

The UF_4 powder is transferred by conveyor to tower reactors where reaction with elemental fluorine produces the final product, UF_6. Elemental fluorine is produced by electrically decomposing hydrogen fluoride (HF). High temperatures in the fluorination towers convert the UF_6 to a gas. The gas enters refrigerated cold traps, which directly solidify the gas. The traps are then heated to liquefy the UF_6, which then can be drained into shipping cylinders. The product in the cylinders returns to ambient temperature and solidifies.

3.1.4 Detailed Description of Cylinder-Filling Process

The cold traps that collect the solid UF_6 product are located on the second floor of the process building. One of these traps is shown in Figure 3.3. There are four primary traps, three secondary traps, and two cleanup reactor traps. While certain traps are valved into the process line to collect the product, others are isolated from the process line and can be heated to enable gravity feed of UF_6 liquid to the cylinders. Still other traps, having been drained of their contents, are evacuated and remain at ambient temperature. The suction available from these traps may be used to draw off UF_6 from cylinders.

An empty cylinder to be filled is placed on a four-wheeled cart, which is propelled on rails by an electric motor. This is shown in Figure 3.4. The cart with its attendant cylinder is moved to one of two drain bays each of which is equipped with scales. The general layout of the drain stations, final weigh stations, and steam chests is shown in Figure 3.5. The cart is moved onto the scales and a scale counterweight (tare poise) is adjusted to cancel the weight of the empty cylinder and the cart, as shown in Figure 3.6. The scales are set to indicate only the net weight of the product as the cylinder is filled, as shown in Figure 3.7. The time required to fill a cylinder may vary from one to several 8-hour work shifts depending on the production rate and the size of the cylinder. The maximum fill capacity for each type of cylinder is posted on a large sign located in the fill bay. There are no warning signs against heating overfilled cylinders, either in drain area or steam chest areas. The operator manually terminates the flow into the cylinder when the targeted fill weight is reached. There is no interconnection between the scales and the fill valve to allow for automatic termination of flow.

The cylinder is filled by attaching a flexible "pigtail" line from a header to the product cylinder valve. This is illustrated in Figure 3.8. The unvented cylinder at this point has been evacuated to facilitate the flow of material into it. The header is instrumented with a gauge to monitor fill pressure and cylinder vacuum. Fill lines are heat traced to prevent clogging and to enable removal of material from the lines after the cylinder is filled. The liquid UF_6 enters the cylinders at a temperature of approximately 210°F.

After the cylinder is filled, the operator closes the valve on the cylinder, detaches the pigtail line from the header, and moves the cylinder off the scales. A fork truck is used to transport the cylinder to one of four steam chests, outside and north of the main process building. The steam chests are covered enclosures, each of which can accommodate one cylinder. The steam chests are shown in Figure 3.9. The steam chest enclosures can be raised or lowered by electric winch. Steam ducts in the chests enable the heating of the cylinder so that the contents can be liquefied and homogenized. Based on reported steam pressures and operating conditions, calculations show that the maximum temperature of the incoming steam, and therefore the maximum temperature attainable for a cylinder in a steam chest, is approximately 250°F. If a cylinder is filled with one draining, or two drainings less than 4 hours apart, procedures provide for immediate sampling without heating. However, if more than 4 hours elapse between drainings the procedures require the cylinder to be heated for 12 hours in the steam chest before it is removed and transported by fork truck to the nearby accountability weight scale room for product sampling. The scale room has a floor scale similar to, but more accurate than, the scales in each of the drain bays. Also available at the accountability weight scale is a header to allow a cylinder to be connected to a cold trap to remove UF_6 for sampling and, as necessary, to attain the allowable shipping weight of the cylinder.

3.2 Chronology of Events Leading to the Incident

The investigation team has constructed the following chronology of events based largely on the interviews of the employees. The statements made by the employees were verified, where possible, by examination of existing records, logs, procedures, etc. No data or information is available that would permit an independent reconstruction of the events. The plant is not equipped with recording instrumentation that would provide such data.

3.2.1 September 20, 1985

Cylinder No. E-2047 is received at the Sequoyah facility, empty except for 45 pounds of residual UF_6 as a "heel" in the cylinder.

3.2.2 September 27, 1985

The cylinder passes a 20-point quality inspection administered by a licensee engineer experienced in the inspection and testing of such containers. The inspection includes visual examinations of valves, welds, and other components for evidence of damage.

3.2.3 January 3, 1986, Day Shift

At approximately 10:00 am, the cylinder is moved from storage to the south drain bay of the process building and is again subjected to the same 20-point inspection by a day shift chemical operator before filling starts. The chemical operator places the cylinder on the south scale and connects it to the No. 4 primary trap and records that 1,230 pounds of product were loaded in the cylinder before the trap was emptied. An additional 10,000 pounds of product are recorded as being drained into the cylinder from the No. 3 primary trap. At the end of the day shift, the chemical operator records that a total of

11,230 pounds of UF_6 has been loaded into the cylinder and that the cylinder is still being filled.

3.2.4 January 3, 1986, Evening Shift

At the end of the evening shift, the chemical operator assigned to the drain station records that an additional 3,140 pounds of product were drained into the cylinder before the No. 3 primary trap was emptied and that 9,060 pounds were added from the No. 2 primary trap. The chemical operator summarizes the record sheet by noting that the net weight of the cylinder is 23,430 pounds at the end of the shift.

3.2.5 January 4, 1986, Midnight Shift

The midnight shift chemical operator has relieved the evening shift chemical operator and is aware that he will complete the filling of the cylinder during his shift. He is assisted by a relief operator. The chemical operator completes his paperwork in advance noting that 4,070 pounds of material are needed to fill the cylinder to his targeted load of 27,500 pounds. The chemical operator initiates heating of a cleanup reactor trap (No. 6 trap) in order to continue cylinder filling. Heating of the trap requires about 1.5 hours to complete. Draining of this trap to the cylinder begins at approximately 2:15 a.m.

At a registered net weight of 26,400 pounds, the chemical operator, observing the lack of weight gain on the scales, concludes that no more material can be added to the cylinder. The chemical operator, who stated that he had never experienced this phenomenon before, investigates the cylinder and its connection to the fill header. He also recognizes that the cylinder has been oriented on the cart in a manner that would not permit the cart to be fully on the scales before the valve end of the cylinder is at its proper position next to the fill header. He discovers that one wheel of the cart holding the cylinder is not fully on the scales. Presuming that this condition affects the scale reading, he attempts to move the cylinder fully onto the scales. To correct this condition, he attempts to activate the cart motor to move the cylinder off the scales so that the fork truck can be used to readjust the position of the cylinder on the cart. However, the electric motor on the cart "trips."

Resetting the motor's breaker permits another try, but this time the motor is unable to propel the back wheel from scale platform to the adjacent floor. The scale platform is aligned at a slight angle with reference to the floor, creating a step of approximately ¼ inch for the cart to overcome. Because of these difficulties, the operator was unable to adjust the position of the cylinder on the cart.

The chemical operator moves the cart in the other direction back onto the scales and manages to orient all of the wheels onto the scale platform. The registered net weight is now about 29,500 pounds on the scales, which have a maximum dial indication of 30,000 pounds.* In effect, the scales have actually "bottomed out" and the actual weight of the material in the cylinder cannot be precisely known.

The chemical operator consults with his supervisor and the decision is made to initiate evacuation of material from the overfilled cylinder by use of vacuum available from previously emptied cold traps. This action is in accordance with the procedures established for this operation. The operator aligns three traps--a primary, secondary, and a cleanup reactor trap--with the header and the cylinder.

The scale counterweight, previously adjusted to counterbalance the weight of the empty cylinder, is now readjusted approximately 6-8 inches to the right to allow the scale dial indicator to move off its physical stop so that when UF_6 begins to flow from the cylinder, a drop in cylinder weight will be indicated. Although this procedure is not contained in a written procedure, it does give the operator the ability to observe weight loss, an important observation. The chemical operator marks the counterweight slide bar with a pen to note the point to which the weight must be returned later in order to indicate the correct weight of the cylinder. Although this introduces some uncertainty for any future measurements, the amount of uncertainty is of little significance, since the error would be small compared to the weight of the cylinder.

The scale dial indicator now reads approximately 28,000 pounds. Later calibration of the tare compensating mechanism indicates that moving the counterweight 6-8 inches would introduce a bias of about 3000 to 4000 pounds. Thus, the estimated weight of the cylinder contents is placed about 31,000-32,000 pounds. Evacuation of the cylinder begins at approximately 6:15 a.m. The relief operator hears the material flowing from the cylinder and notes that the scale dial indicator drops approximately 150 pounds in the first 10 minutes of evacuation.

At the end of the shift, the chemical operator records on the cold trap and product cylinder status sheet that the cylinder has been overfilled because the cart was not fully on the scales. The chemical operator briefs the oncoming day shift chemical operator (who had originally placed the cylinder cart on the scales) regarding the status of the cylinder and the scales.

3.2.6 January 4, 1986, Day Shift

The day shift supervisor is absent, having taken the day off because of earlier overtime worked, and the assistant shift supervisor is the ranking production manager on site. Although there is no formal succession of authority delineated by Sequoyah Fuels Corporation, the accepted practice is for the authority and responsibility to pass downward. Although the assistant shift

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* The scale has a built-in mechanism that limits the extent of travel of the dial indicator. Subsequent examination of the scale mechanism showed that this mechanism was adjusted so that the dial indicator movement is physically stopped at an indicated reading of 29,760 pounds, about 1% above what the operator reported as having observed.

supervisor normally oversees work in areas of the plant other than product draining and shipping, he is familiar with the area because he had formerly worked there as an operator.

The assistant shift supervisor stated that the day shift chemical operator, on the basis of observations of manifold pressure, had concluded that he was no longer able to draw off additional material from the cylinder presumably because the UF_6 had begun to solidify. The operator consults with the assistant shift supervisor, who tells the operator that they will transfer the cylinder by forklift to a steam chest located outside the process building.*

Before moving the cylinder, the operator reweighs it by returning the counterweight to its original position. The dial indicator is observed by the assistant shift supervisor and a maintenance worker, both of whom stated to the investigation team their belief that the indicator was free (not pegged) and that it indicated approximately 29,500 pounds.** The operator then closes the fill valve on the cylinder and detaches the cylinder from the fill header.

The assistant shift supervisor and the chemical operator move the cylinder to the northwest steam chest. The assistant shift supervisor manually turns on the steam supply to commence heating. It was his instruction to heat the cylinder for 6 hours to liquefy the UF_6. The cylinder is then to be returned to the process building so that material extraction can be resumed. After the cylinder is moved to the steam chest, the chemical operator continues his other duties in and about the process building while the cylinder is heating. (As is usual during heating of cylinders in steam chests, the fill valve is closed and no means of venting the cylinder is provided during heating.)

3.3 Chronology of Events During and After the Incident

At approximately 11:30 a.m., the cylinder ruptures in the steam chest causing the cylinder to spin in its cradle. The 4-foot, lengthwise rupture which occurred along the top of the cylinder is oriented approximately 120 degrees from its

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* Heating an overfilled cylinder is prohibited by Sequoyah Fuels Corporation Procedure No. N-280-1, Revision 6, dated January 23, 1985. (Pertinent Sequoyah Fuels Corporation procedures are included as Appendx D.)

** There is no way to confirm or deny this observation by the assistant shift supervisor and the maintenance worker. It is not consistent with other information gathered by the investigation team. Observation of the physical limitations on the scale movement, and inferences drawn from testimony as to the relative amount of material withdrawn from the cylinder lead to the conclusion that the indicator was likely not free to move and give a true reading.

initial position after the cylinder comes to rest. The force of the explosion also ruptures the top of the steam chest enclosure. (See Figures 3.10 and 3.11.) Liquid UF_6 flows from the rupture and rapidly reacts with moisture in the air to form uranyl fluoride (UO_2F_2) and hydrofluoric acid (HF). The resulting vapor cloud is carried south by southeast by a wind gusting to 25 mph.

The cloud envelopes the process building, and the acidic vapor fatally injures the chemical operator now located within a scrubber building (shown in Figure 3.12) approximately 70 feet southwest of the cylinder. Other workers nearby include a worker in the maintenance bay located on the north side of the process building and the assistant shift supervisor, who is in the protective clothing change room south of the main process area. The vapor quickly enters the ventilation intake vents of the process building and is visible to employees. Most of the approximately 40 workers at the site are in the lunch room and quickly evacuate the building through the south door near the plant offices or the west door from the process area. Many workers had to pass through the vapor cloud during their evacuation. The fatally injured operator also evacuates through the south door.

An operator in the control room of the plant sounds an evacuation siren that automatically shuts down the ventilation system to the building. He also shuts down critical plant processes before he himself evacuates. Workers reassemble near mobile trailers used by contractors and located northeast and upwind of the process building. The airborne release continues for approximately 40 minutes before ending.

The licensee's Manager, Health Physics and Industrial Safety, is on site at the time of the incident and takes the lead in the licensee's onsite immediate response to the incident. The manager stated to the investigation team that within 10 minutes he went to a construction area upwind from the accident and, assisted by two secretaries, started to notify personnel who were not on site. In addition, the licensee's Director of Licensing and Regulation in Oklahoma City joins in to notify authorities. Notification includes:

(1) A private physician in nearby Vian is notified and proceeds to the site. Upon arrival at 12:15 p.m., the physician examines workers who have not been transported to a hospital.

(2) The Sequoyah County Hospital in Sallisaw is notified that four injured workers are being transported by private automobiles to the hospital.

(3) The Director of Nuclear Licensing and Regulation in the licensee's corporate office in Oklahoma City is notified of the incident and briefed on the conditions at the facility and the status of injured personnel. The Director of Nuclear Licensing and Regulation, assisted by other staff personnel, notifies the Oklahoma State Department of Health; the U.S. Nuclear Regulatory Commission (through a staff member of the Office of Nuclear Material Safety and Safeguards); Oklahoma Highway Patrol in Muskogee, Oklahoma; the Sallisaw, Oklahoma Police Department; and other members of the corporate staff of Kerr-McGee and Sequoyah Fuels Corporation. The NRC Region IV Duty Officer is notified of the incident by the NRC:HQ Duty Officer by pager at approximately 12:25 p.m. The

Region IV Incident Response Center is manned, and communication links with NRC headquarters and the licensee begin at 12:55 p.m.

(4) The Gore, Oklahoma Police Department is notified and requested to assist in notifying other law enforcement agencies and to block Interstate 40 and Oklahoma State Highway 10 to prevent traffic flow through areas that may have been affected by the release. The Gore Police Department notifies the Sequoyah County Sheriff's Department and the Oklahoma Highway Patrol in Sallisaw, Oklahoma, to initiate traffic control to the facility and areas along Oklahoma State Highway 10 and Interstate 40 affected by the incident.

(5) Critical plant personnel offsite are notified and requested to come to the site. Included are all health physics technicians. After several hours, the licensee requests additional support from Sequoyah Fuels Corporation's Cimarron facility near Crescent, Oklahoma.

(6) The general public is first notified by local radio. Nearby residents in the path learn of the accident in various ways. For example, an employee at the facility calls his wife and tells her to get the children and drive away from the cloud. Another resident sees the cloud, calls a local health department, and receives the same advice. The Manager of Personnel at the Sequoyah facility and a representative of the Gore Civil Defense goes to each home southeast of the facility, starting at about 12:30 p.m. He advises those residents he finds at home to go to a hospital for an examination. He explains that the cylinder explosion had caused a release of hydrogen fluoride. Kerr-McGee also releases this message to the media, urging all residents who were in the cloud's path to go to nearby hospitals and clinics for examinations.

According to workers who were involved, the first persons on the scene of the ruptured cylinder found UF_6 solids dispersed over a wide area. The reportedly small pieces were evidently ejected from the cylinder with great force when it ruptured.

Even though the initial breach of the cylinder caused a large spontaneous release of airborne fumes and vapors, the dispersed UF_6 continued to evolve fumes and vapors, contributing to the total release. The first actions taken by those on the scene were to bring in fire hoses and spray the area with a fine mist of water created by "fog" nozzles on the firehoses. While the fine water spray tended to accelerate the hydrolysis of the UF_6, it also probably reduced the effects of the release through the physical "scrubbing" action of the water droplets and dilution of any vapors that escaped.

At the same time as the area was being sprayed, workers took steps to quench the flow of fumes and vapors which continued to escape from the damaged cylinders. A large number of towels and rags were soaked in water and stuffed into the opening of the damaged container. The evolving UF_6 reacted with the water in the towels, forming uranyl fluoride, which formed a crust-like material that helped to seal the pores in the towel fabric and make the temporary plug effective.

These mitigative actions continue for 30-40 minutes after the initial release. The large amount of contaminated water generated flowed mostly to the northwest, where it was intercepted by a drainage ditch and eventually collected in a holding pond.

Health physics technicians arrive at approximately 1:00 p.m. Local, state, federal, and company officials arrive at the site during the ensuing hours, and recovery operations begin.

Representatives of NRC's Region IV office and the Oklahoma State Department of Health's Occupational and Radiological Health Service arrive at the site at 6:00 p.m. Representatives of the Occupational Safety and Health Administration visit at the site on Monday, January 6, 1986.

3.4 Preliminary Assessment of Cause of Cylinder Rupture

3.4.1 Conclusion

As a result of its preliminary investigation at the site immediately after the incident, the investigation team concludes that the cylinder was not defective but failed because of stress caused by hydraulic pressure that was due to the expansion of UF_6 in the cylinder when it was heated.

3.4.2 Cylinder Description

The cylinder is a Model 48Y container with a capacity of approximately 14 tons of UF_6. It is made of 5/8-inch-thick steel. The body of the cylinder is approximately 117 inches long with an inside diameter of 48 inches. Three circumferential stiffening rings are welded around the outside of the cylinder body. Semiellipsoidal heads, also made of 5/8-inch-thick steel, are welded to each end of the cylindrical body. The container has an overall length of 146 inches. The nominal weight of an empty Model 48Y cylinder is 5,200 pounds. The maximum net weight of the contents is not intended to exceed 27,560 pounds.

Model 48Y cylinders are designed for a service pressure of 200 psig. Each container is hydrostatically tested to 400 psig at the time of fabrication and at 5-year intervals thereafter. In addition, the container is visually inspected when it is received and before it is loaded.

The following information was stamped on the nameplate of the cylinder that ruptured:

Serial No.: 32047
Manufactured: May 5, 1977
Water Capacity: 4,072 Kg
Max. Wt. of pure UF_6: 12,501 Kg [27,560 pounds]
A516 Steel Tensile 70,000 psi
Last hydrotest: September 15, 1982
Owner: El Dorado Nuclear*
Manufacturer: Trinity Industries, Dallas, Texas

*Kerr-McGee had subsequently acquired ownership of the cylinder.

3.4.3 Cylinder Damage

A visual examination of the damaged cylinder was made on January 6, 1986. Although a large portion of the cylinder was covered by the steam chest, a sufficient area was exposed to reveal the nature and extent of the damage. The cylinder was oriented so that the fill valve which is normally at a 12 o'clock position, was in approximately an 8 o'clock position.

The cylinder was ruptured for a distance of approximately 52 inches in the axial direction along a line passing through the location where the stiffening rings were butt welded closed. The crack resembled a long, narrow slit, approximately 8 inches wide at the widest point. The crack did not appear to be jagged or irregular. (See Figure 3.13.)

The three circumferential stiffening rings were separated at the point where they were previously welded closed. The shell bulged radially outward with the maximum deformation appearing to be halfway between the stiffening rings. The cylindrical shell had undergone considerable plastic deformation in both the region of the rupture and in regions away from the rupture at the opposite end of the cylindrical shell. Figures 3.14 through 3.16 show this damage.

The cylinder did not rupture along its longitudinal seam weld. The longitudinal weld is approximately 6 inches away from the longitudinal rupture crack. From the nature of the damage, it is evident that the internal pressure was large enough to produce stresses exceeding the yield strength of the material. At the service pressure of 200 psi or even the hydrostatic test pressure of 400 psi, the stresses in the shell would be well below those needed to cause general yielding or extensive outward radial bulging. The evidence suggests that the shell was subjected to an internal pressure substantially greater than the 400-psi hydrostatic test pressure before the rupture occurred. The internal pressure needed to produce the onset of general plastic deformation was calculated to be about 1,000 psi, assuming material and dimensions as described by the manufacturer. Similarly, the internal pressure required to actually rupture the cylinder was calculated to be approximately 2,000 psi.

3.4.4 Analysis of Damage

The plastic deformation of the shell before rupture indicates that the failure was ductile in nature rather than brittle. Brittle fracture is characterized by crack propagation driven by elastic strain energy. Because the material was strained well beyond its elastic limit, the failure mode was not brittle fracture. Also, if the shell had failed in a brittle manner at stress levels below yield, the loss of contents would have reduced the pressure so that general yielding of the shell would not have occurred in regions of the shell away from the rupture.

Figure 3.17 graphically depicts the relative volumes occupied by UF_6 in a normally filled cylinder when the UF_6 is in the solid phase at 100°F and the liquid phase at 200°F and 250°F. The UF_6 undergoes an increase in volume of about 36% when it changes from solid to liquid form at 147°F. Large internal pressures can be produced hydraulically when liquid contents expand to a volume greater than the volume of the vessel in which they are contained.

The Model 48Y cylinder that failed is suspected of having been loaded with substantially more UF_6 than its fill specification of 27,560 pounds. At the time of failure, the overloaded cylinder was being heated in a steam chest. Although the quantity, purity, and temperature of the cylinder contents are not known precisely, heating of the overfilled cylinder is judged to have caused the cylinder to fail by hydraulic rupture. Listed below are temperatures and associated quantities of UF_6 with which the cylinder can be filled:

Temperature (^{o}F)	UF_6 Density (lb/ft /3)	Quantity to fill (lb)
146	303.8 (solid)	43,784
147	227.7 (liquid)	32,816
200	215.6	31,072
235	207.1	29,847
250	203.3	29,300

Because of the long (approximately 20-hour) fill interval during which the cylinder was at ambient temperature, it is likely that a portion of the material solidified and shrunk in the cylinder before it was completely filled. This would have enabled additional material to have been added to the cylinder. When the cylinder was heated in the steam chest, this solid portion would have liquefied and expanded to cause the rupture. The above data suggest that a cylinder heated to 200^{o}F in the steam chest would have had to be filled with more than 31,072 pounds of material in order to rupture by the above-described mechanism. In the limited time the cylinder was in the chest, it is not likely that the temperature would have exceeded this value.

As noted earlier (see 2.5), a detailed metallurgical examination is underway. Early results are consistent with these preliminary findings.

3.5 Personnel Training

Sequoyah Fuels Corporation Procedure N-280-1, "Uranium Hexafluoride Product Handling and Shipping," Revision 6, which was approved by facility management on January 28, 1985, states in two places within the portion of the procedure regarding cylinder filling:

> Note: Do not heat a cylinder which has been overfilled. Evacuate the overfilled cylinder without heating until the maximum net weight is attained. This is necessary to prevent rupture of the cylinder due to hydrostatic pressure.

The assistant shift supervisor stated that he could not remember receiving or being indoctrinated in this procedural requirement. He directed that the overfilled cylinder be placed in the steam chest to liquefy the contents so more material could be removed.

The NRC investigators reviewed the licensee's program for establishing, approving, and maintaining plant operating procedures and the program for training workers in regard to their jobs and the contents of the procedures. The investigators obtained information in these areas through interviews of plant workers and managers and through subsequent review of pertinent records.

Area supervisors have written or coordinated the writing of new procedures. The facility manager has then approved the procedures before they have been distributed through plant mail to line management personnel. The procedures showed evidence of having been reviewed and revised over many years because issue dates ranged from the early 1970s through 1985 and revision numbers were sometimes well advanced.

The mechanism for training personnel in procedures was found to be weak in that there has been no formalized plan or procedure for accomplishing this task, and supervisors have been left to their own devices to see that their workers are made aware of procedure contents. Some supervisors have distributed copies to workers; others have only notified workers of new issues and have made available a set of procedures at various locations within the plant.

Many of the shift supervisors and workers stated that procedure contents have been discussed during safety meetings held by supervisors with their workers each month. A review of safety meeting minutes by an NRC investigator disclosed that the meetings have served as a forum for a wide variety of discussions ranging from worker stress and how to safely jump start a car to operator training and discussion of procedures. However, minutes for the past year indicated that there had been a discussion on two of the four shifts regarding Operating Procedure N-280-1 and operator training for cylinder shipping and handling. There is no record of training in these procedures for the shift on which the incident occurred.

Licensee management stated that a program for reviewing all operating procedures had begun during July 1985 whereby all shifts would allocate 2 hours per month to classroom review of procedures with a view to completing the task within 12 months. Interviews with workers confirmed that this training had been initiated, but most of those interviewed said that Operating Procedure N-280-1 had not yet been covered.

An interview of workers disclosed that some were well acquainted with the procedures, that they had acquired their own procedure copies as necessary, and that they had studied them on their own. Other workers were far less acquainted with procedures and their contents. One interviewed worker currently assigned to cylinder filling duties stated that he had never seen the procedure or received training in regard to Operating Procedure N-280-1.

The NRC investigators found that new workers received only on-the-job training. Supervisors have provided initial orientation to new employees and have then assigned them to an experienced worker who has taught them the details of their assigned tasks. There also has been no formal testing of workers either orally or in writing before they take independent responsibility for assigned tasks.

Workers and supervisors stated during interviews that chemical operators were required to complete a self-study course created by DuPont that dealt generally with basic plant physical science and mechanics such as gauge reading and physical phenomena, but none of this training had focused on particular processes at the conversion facility or on specific operator assignments.

3.6 Staffing Adequacy

On the day shift, Saturday, January 4, the Shift Supervisor was not on duty, having taken the day off because of overtime worked earlier. In addition, the area supervisors were not on duty, since it was Saturday, a normal day off for them. As a consequence, the assistant shift supervisor was the ranking individual present and, according to common practice, was in charge of the shift operators.

The question that this arrangement raises is whether or not the number and makeup of personnel available made any discernable contribution to the accident.

There is no way to realistically assess whether the incident would have taken a different course if the shift supervisor had been present. Such speculation would serve no purpose. His absence does not appear to have put an undue burden on the assistant shift supervisor. From his interview, and those of others, there does not seem to be any demands on his time or attention that would have contributed to the incident.

Since the area supervisors work the day shift Monday through Friday, it is common for the area supervisors to be absent during shift operations. The situation on the Saturday day shift was no different than that on the evening and midnight shifts during the rest of the week. In their absence, the shift supervisor and assistant shift supervisor carry out their assigned duties. On the day of the accident, the assistant shift supervisor telephoned his area supervisor to discuss operations. Thus, the relationship between the shift workers and the area supervisor was normal and does not seem to have contributed to the incident.

A frequently voiced comment by those interviewed was that the number of workers assigned to production shift work was frequently insufficient to carry out the normal duties assigned to them. For example, operators often leave some operations unattended in order to provide assistance in a job where two persons were required. The effect of this reported understaffing on the incident cannot be judged. In reviewing the events leading up to the accident, there is nothing that was reported that would lead to a conclusion that the general level of staffing made any direct contribution to the accident. Indirect effects on worker morale, efficiency, and work habits were beyond the investigation team's ability to judge.

What the investigation team concludes from their consideration of this question is that any contributions to the causes of the accident that resulted from the size and makeup of the work force are not identifiable, if they exist. What is a much more important factor than the number and titles of the workers is how well they were trained to do their jobs. As noted earlier, this was clearly a deficiency in the Sequoyah Facility's operations.

FIGURE 3.1

SEQUOYAH FACILITY

PRODUCTION DEPARTMENT ORGANIZATION CHART

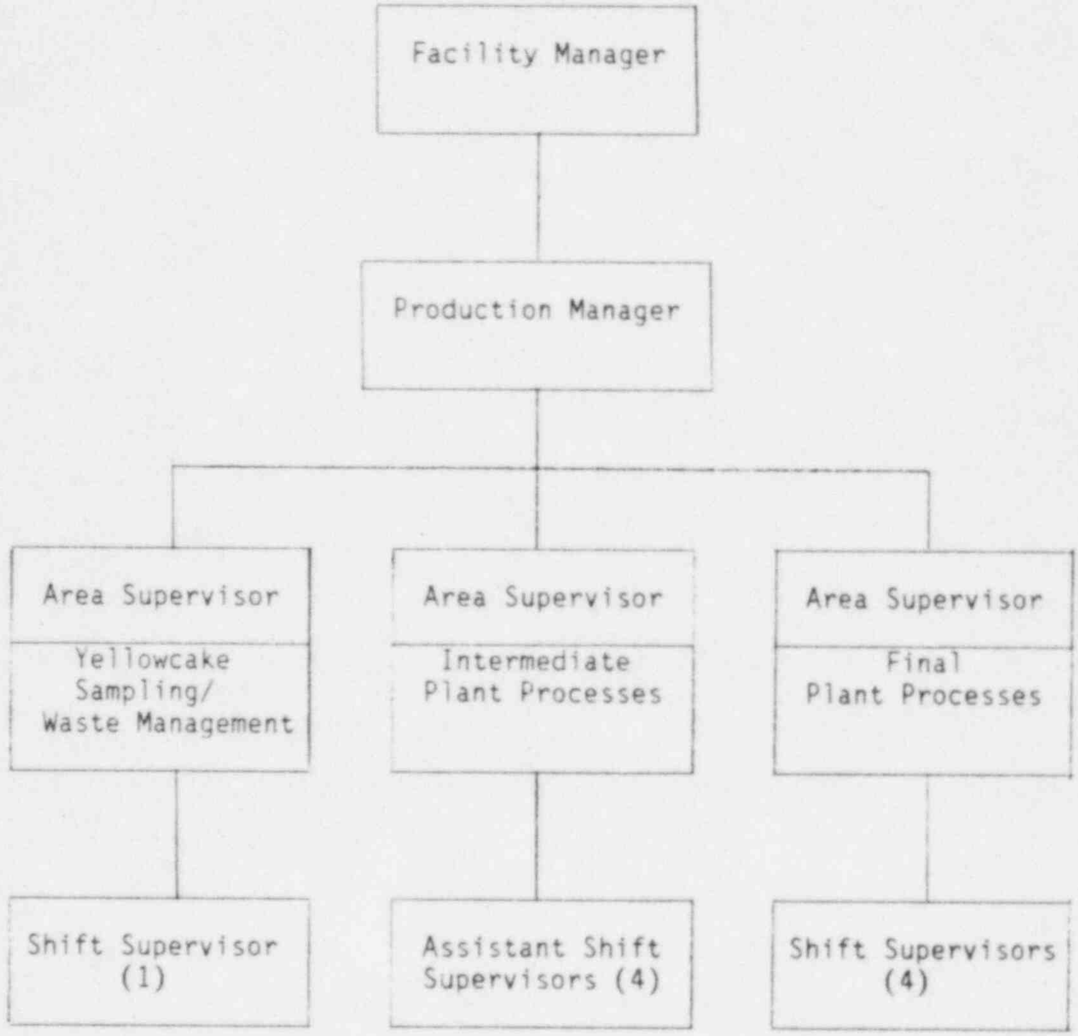
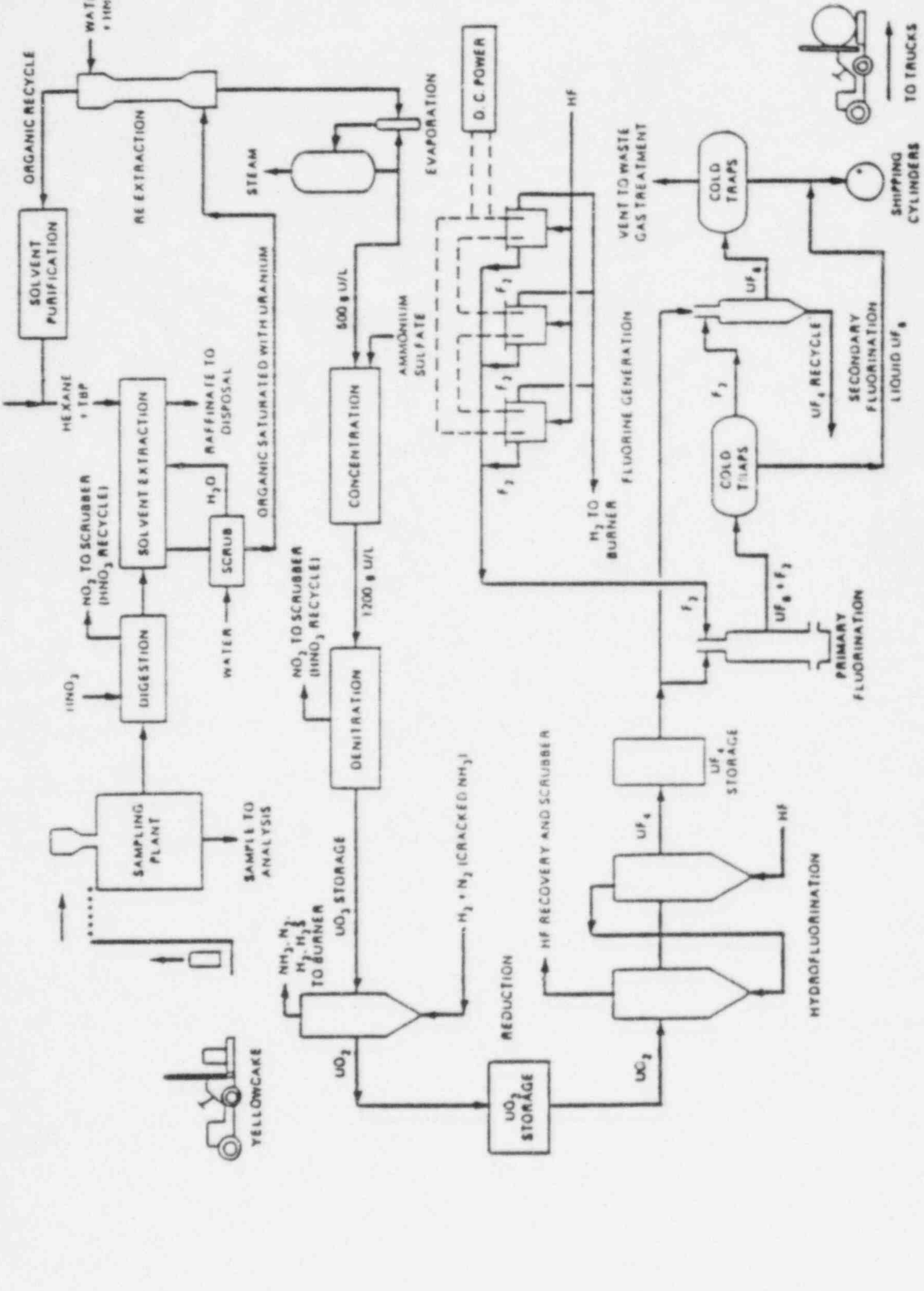


FIGURE 3.2

UF_6 CONVERSION FLOW CHART



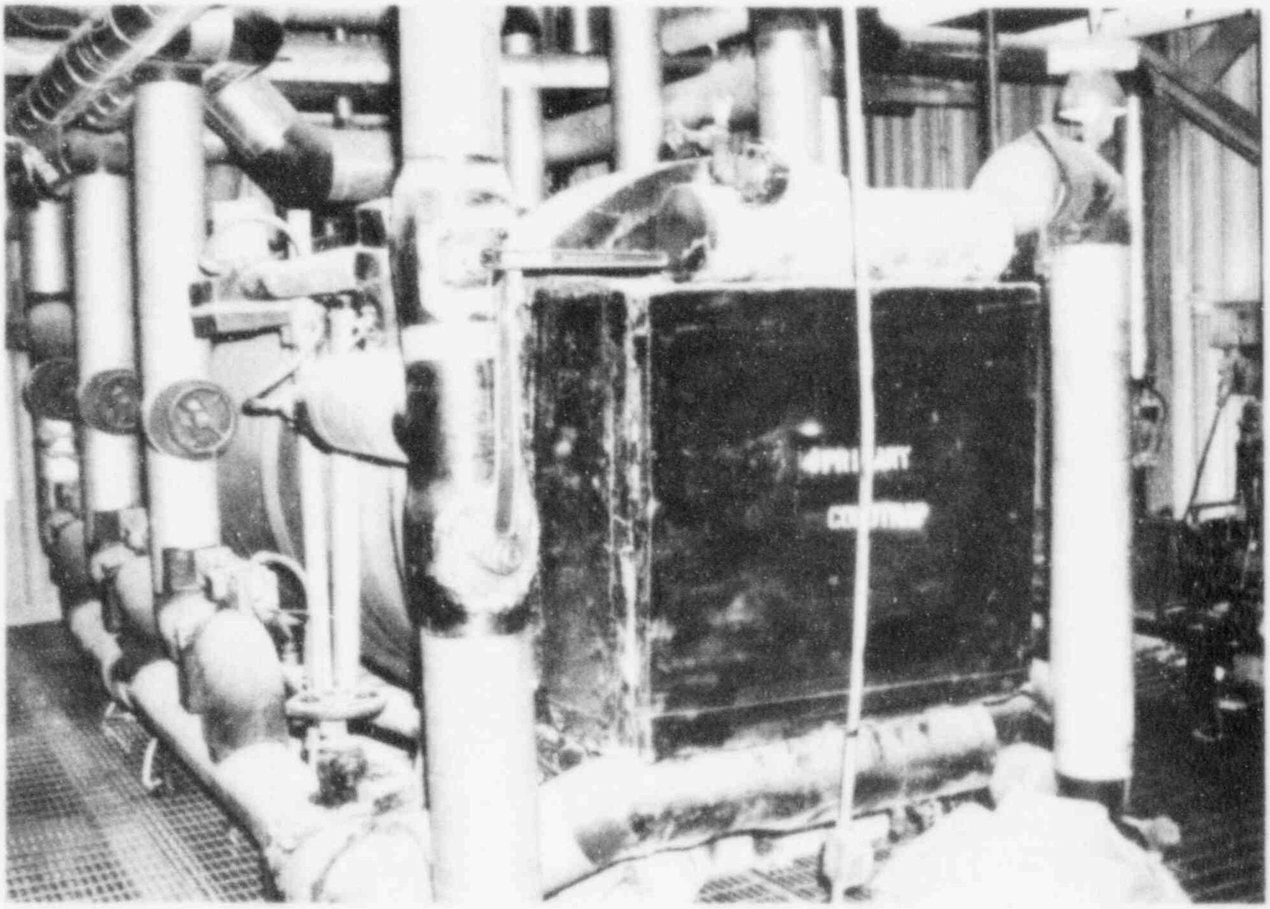


Figure 3.3 UF_6 cold traps

Cold traps receive gaseous UF_6 and condense the material to a solid form. When loaded, traps are heated to liquefy the UF_6 for draining to cylinders, two floors below.

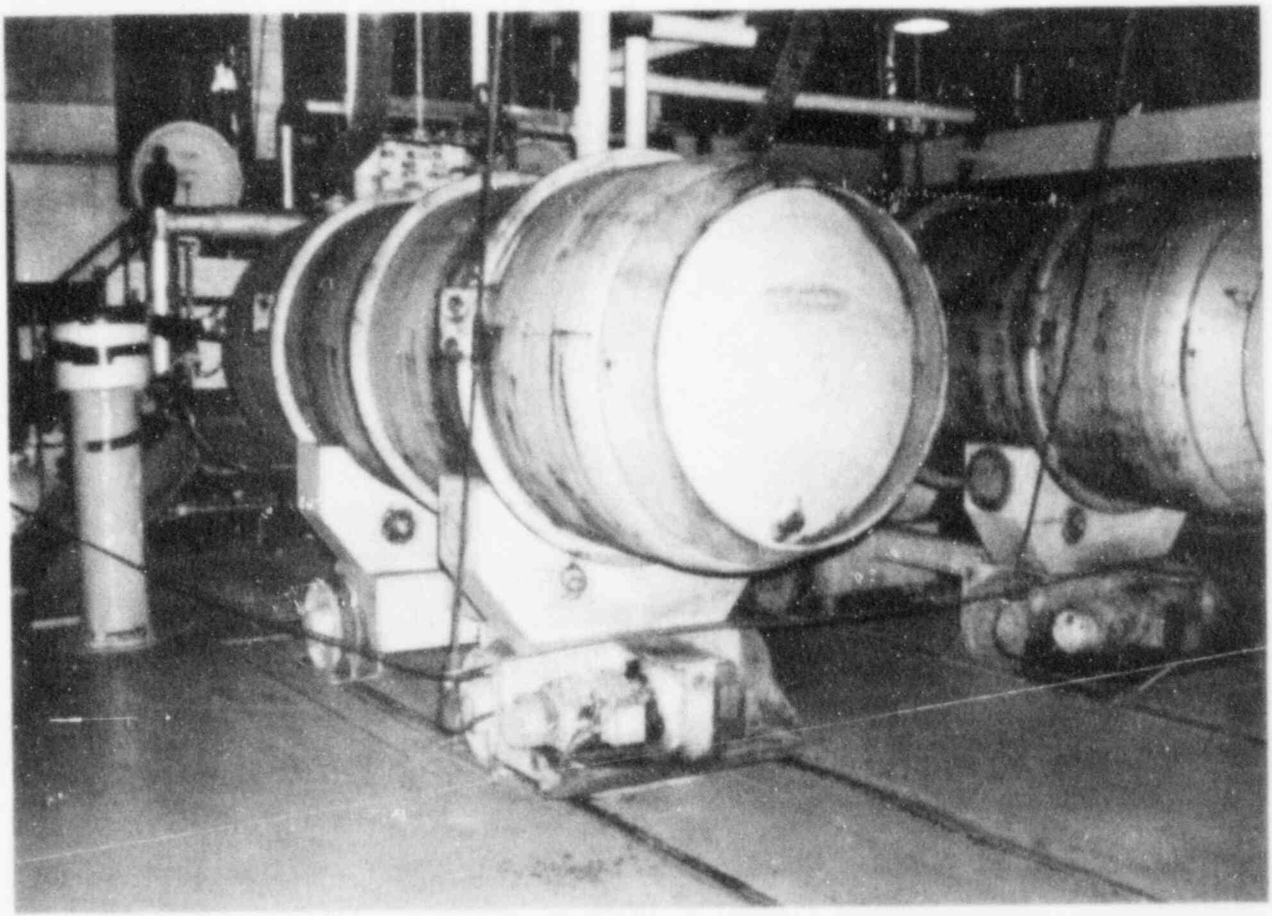
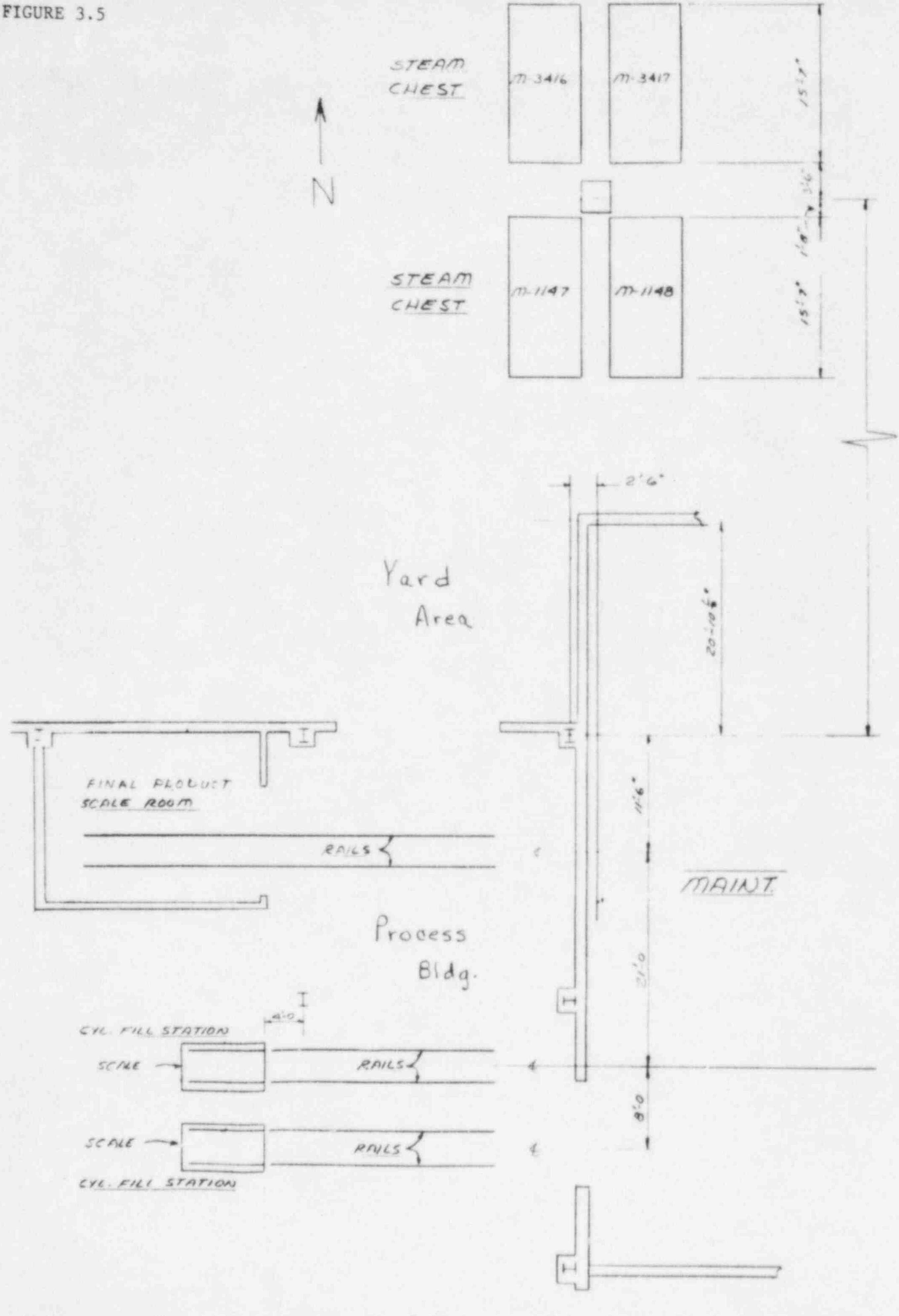


Figure 3.4 Cylinder-loading stations

Two 14-ton cylinders are positioned on scale platforms to receive liquid UF_6 from heated cold traps overhead. Weight is observed on a large dial indicator in the background.

FIGURE 3.5



STEAM CHEST
M-3416
M-3417
15'7"
3'6"
1'6"
STEAM CHEST
M-1147
M-1148
15'7"
N
2'6"
20'-10 ⅝"
Yard Area
FINAL PRODUCT SCALE ROOM
RAILS
11'6"
MAINT.
Process Bldg.
21'0
4'0
CYL. FILL STATION
SCALE
RAILS
8'0
SCALE
RAILS
CYL. FILL STATION

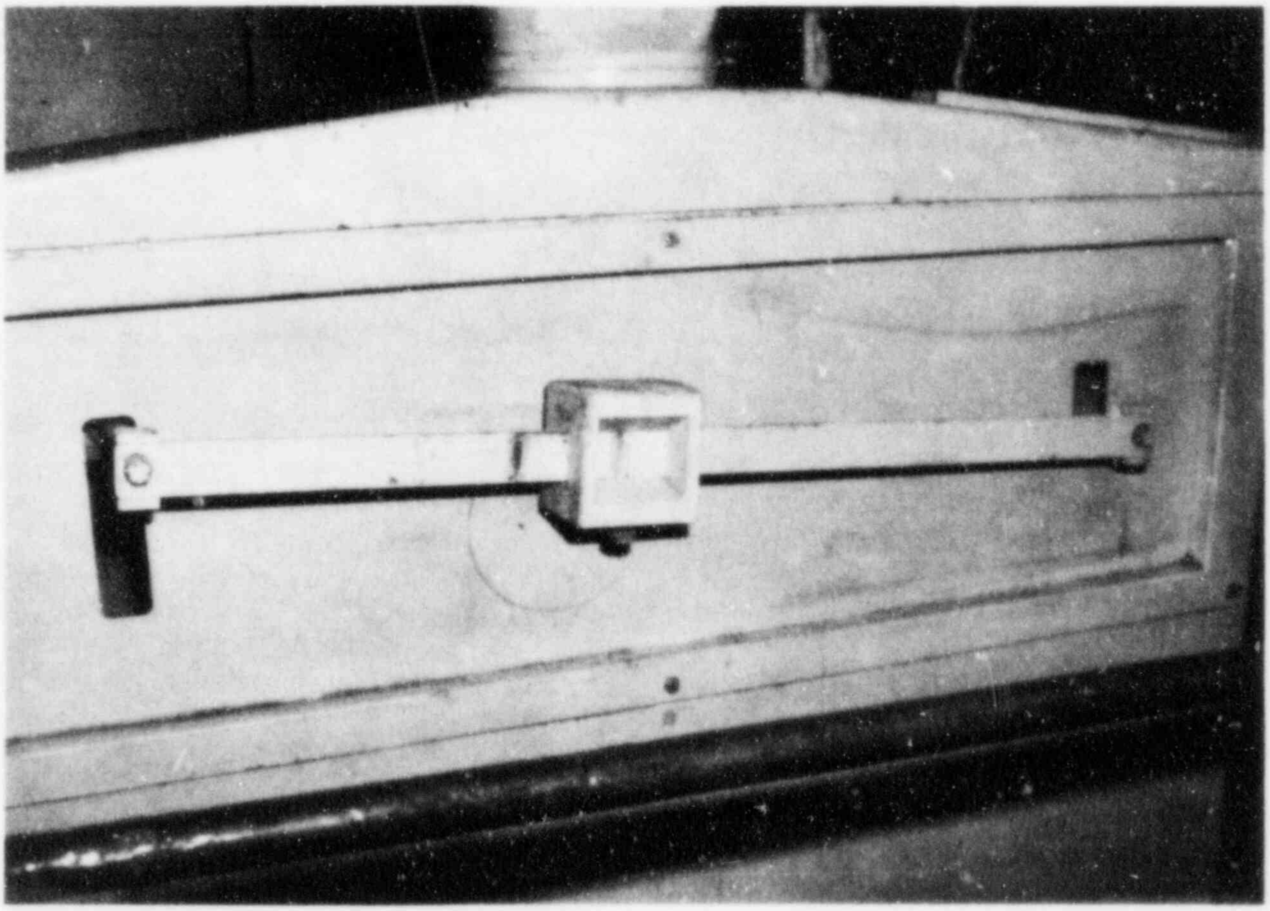


Figure 3.6 Tare-compensating weight

The tare weight of an empty cylinder and the cart is eliminated from the observed weight by moving the poise on the beam until the dial indicator reads zero.

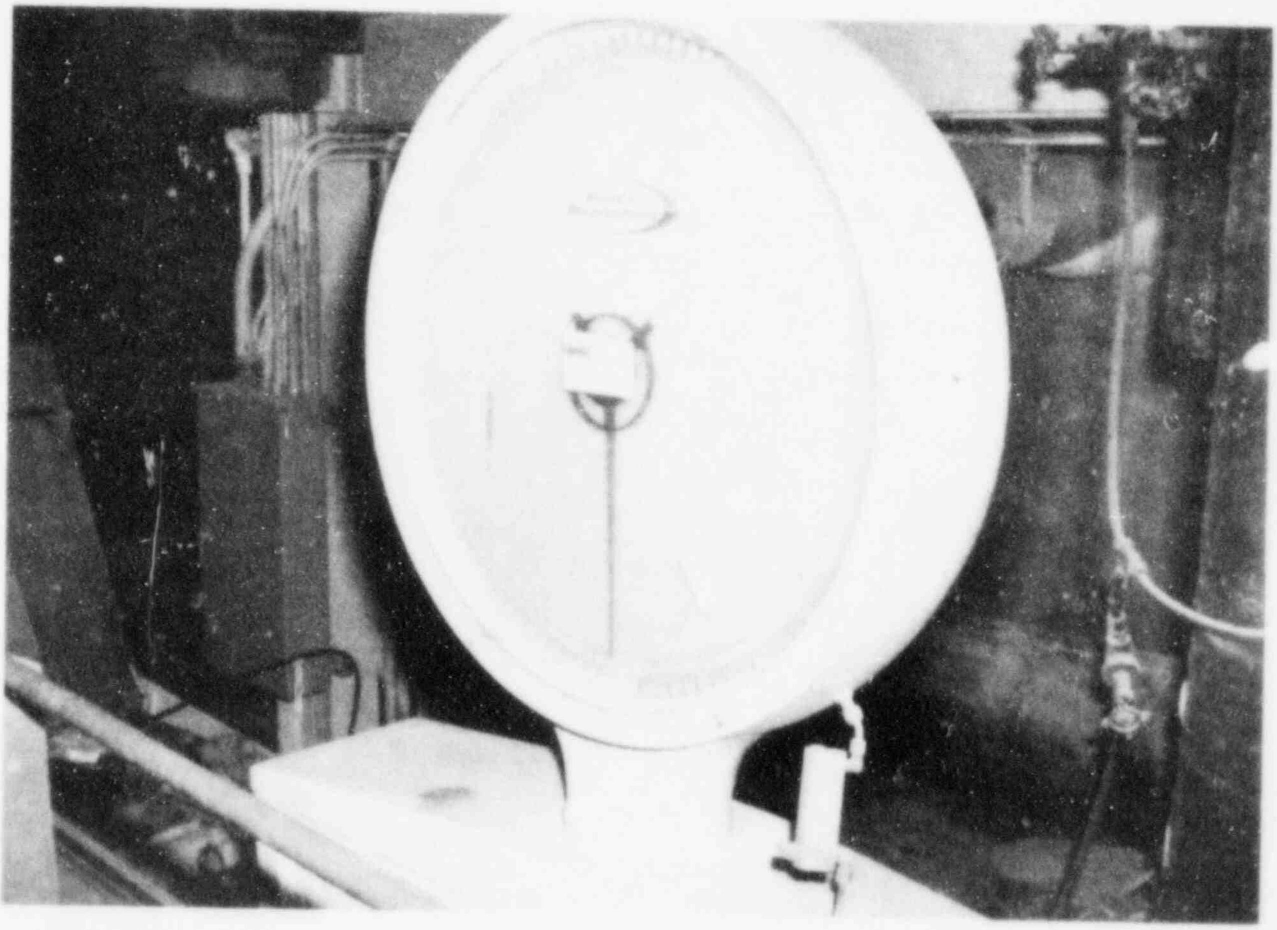


Figure 3.7 Scale dial indicator

With an empty cylinder on its cart and the tare-compensating mechanism adjusted to zero, the dial indicator records the net weight of the cylinder contents.

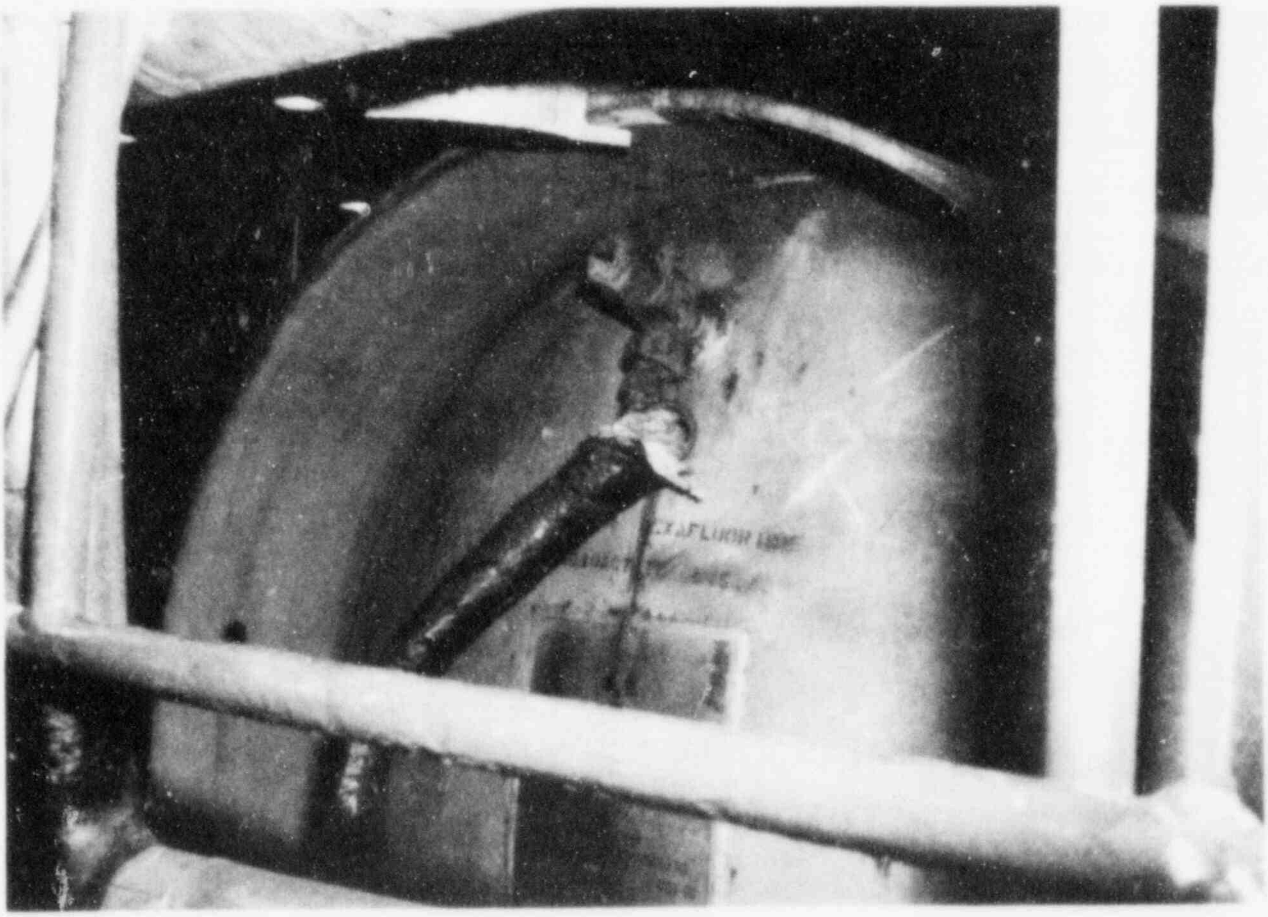


Figure 3.8 Flexible cylinder connection

Liquid UF_6 enters the cylinder through this flexible line, which is connected to the cylinder fill valve.

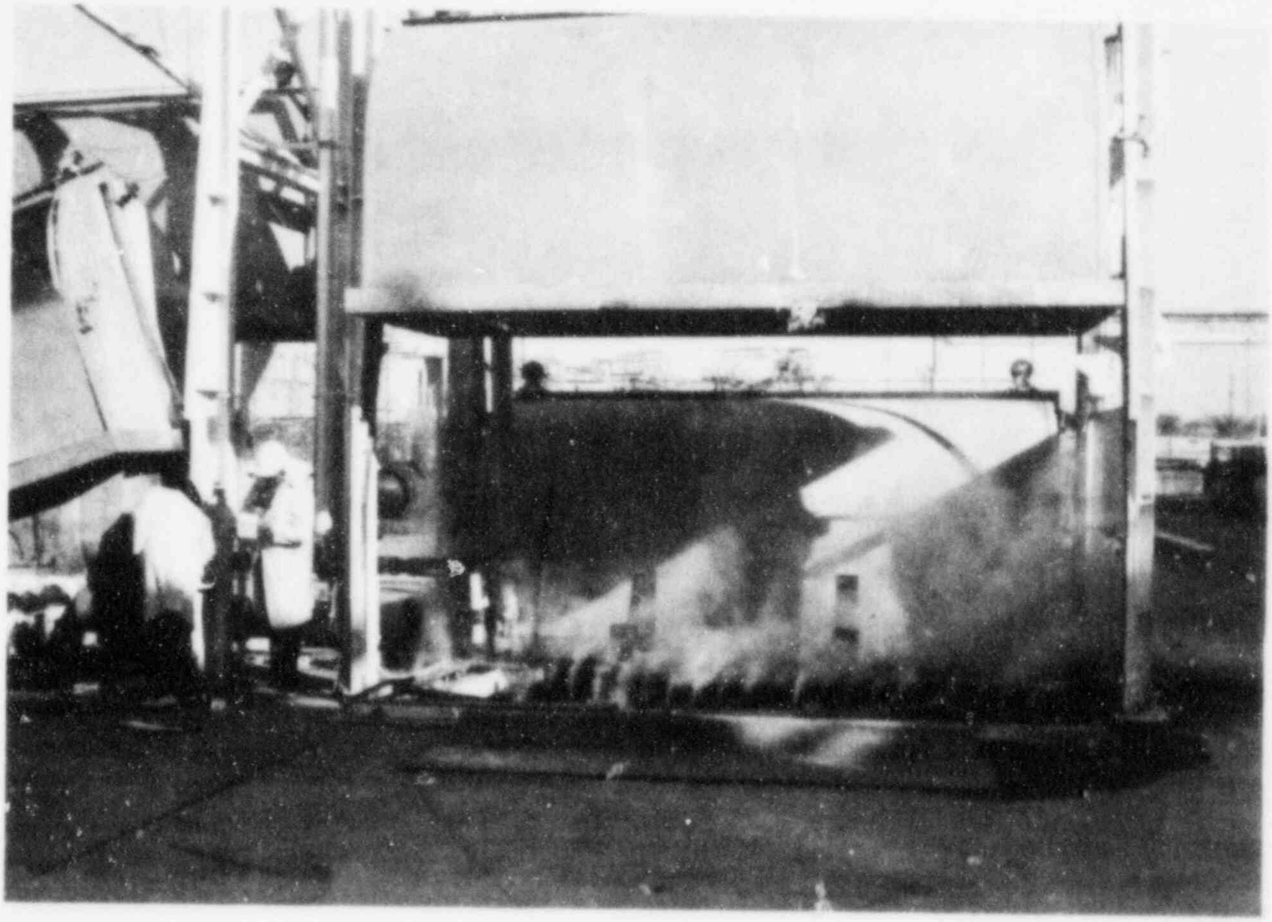


Figure 3.9 Steam chests

Two of the undamaged steam chests are shown. The nearer chest cover has been raised, showing the cradle on which the UF_6 cylinder is placed and the steam manifold through which steam is introduced. In the background, the cover has been lowered for heating.

Figure 3.10 Ruptured cylinder

The ruptured cylinder, with its temporary rag plug in place, rests in the damaged steam chest. The fill valve, in the 8 o'clock position on the near end of the cylinder, was at 12 o'clock before the rupture occurred.

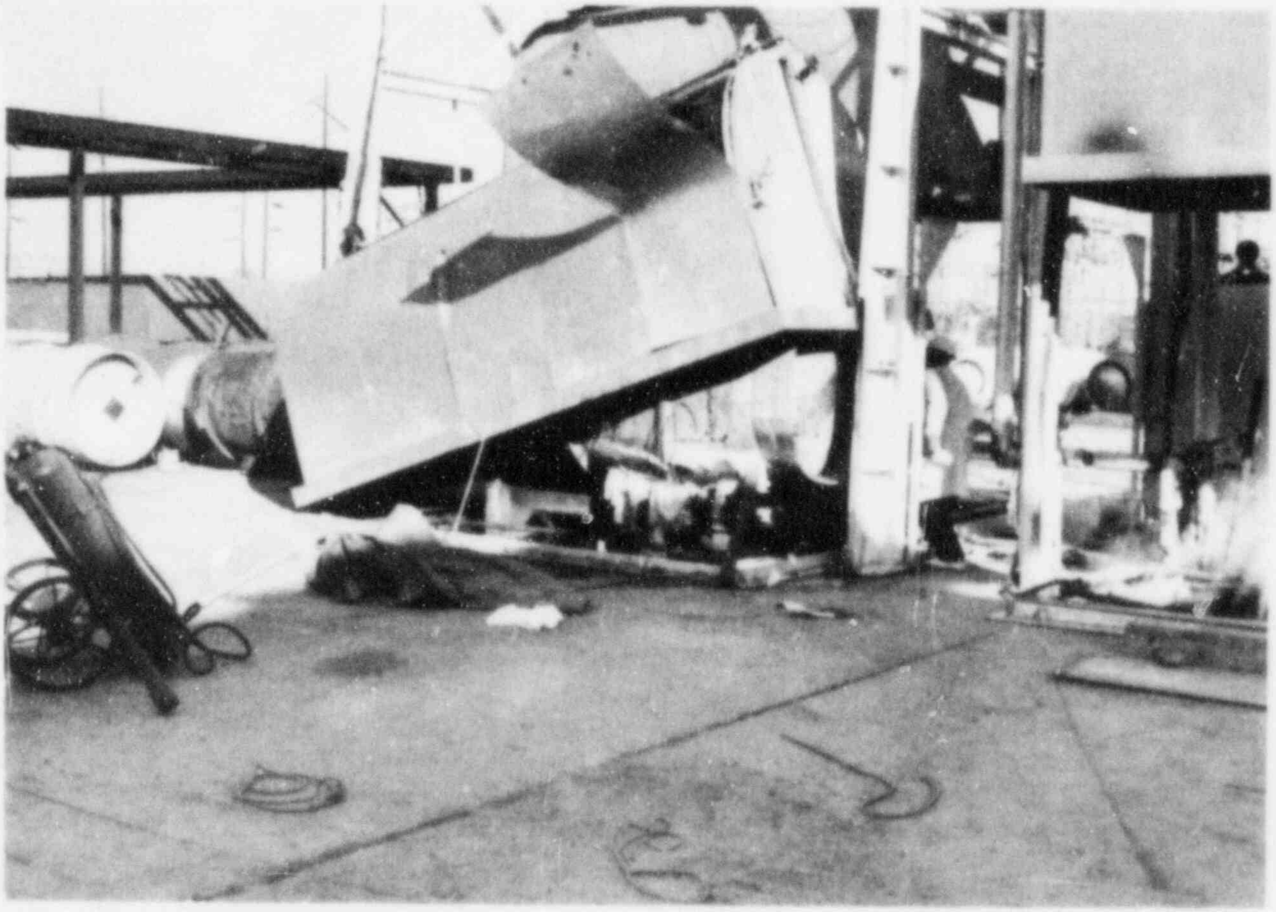


Figure 3.11 Damaged steam chest and cylinder

The force of the release caused damage to the steam chest cover.

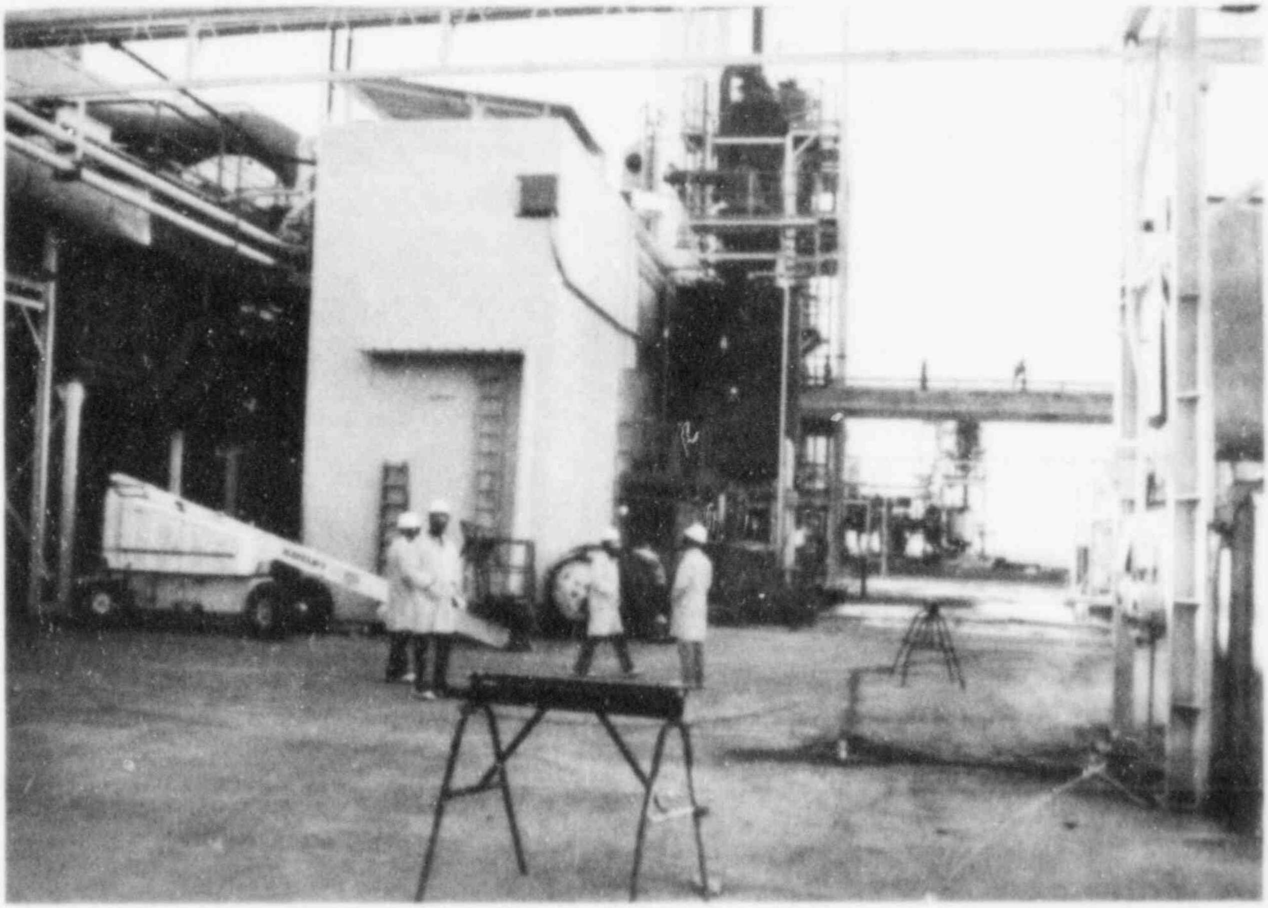


Figure 3.12 Scrubber building

The worker who was fatally injured was working on the upper level of the two-story white structure. He was engulfed by a cloud of vapors and gases consisting of hydrofluoric acid (HF), uranyl fluoride (UO_2F_2), and uranium hexafluoride (UF_6). The nearest steam chest is barely visible at the right edge of the photograph.

Figure 3.13 Damaged portion of the cylinder

The rupture is shown in this picture, which was taken shortly after the temporary rag plug was removed. The cylinder has been rotated from its position immediately after the accident.

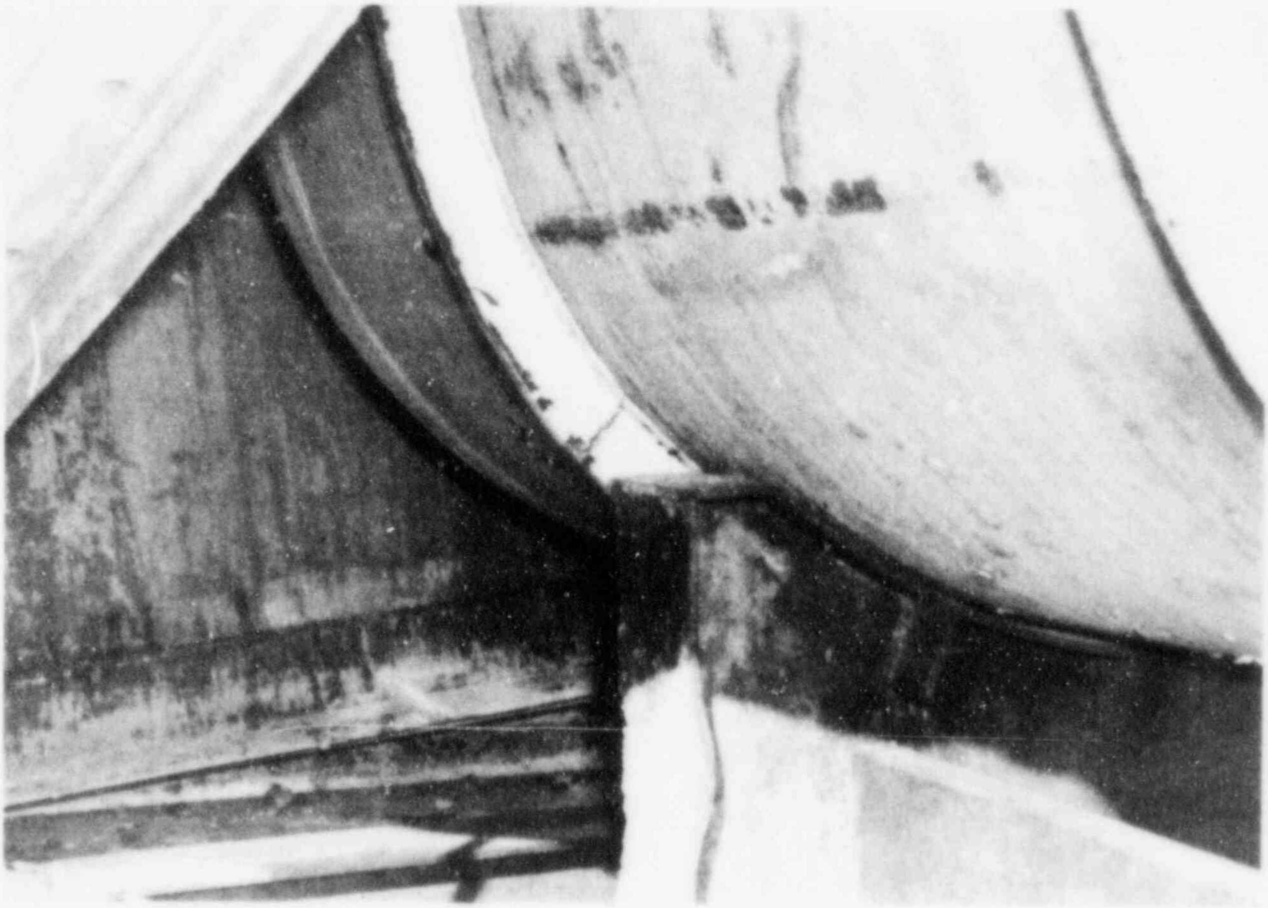


Figure 3.14 Separation of stiffener ring

The stiffener ring farthest from the rupture clearly shows separation at the butt weld joining the ends of the ring.

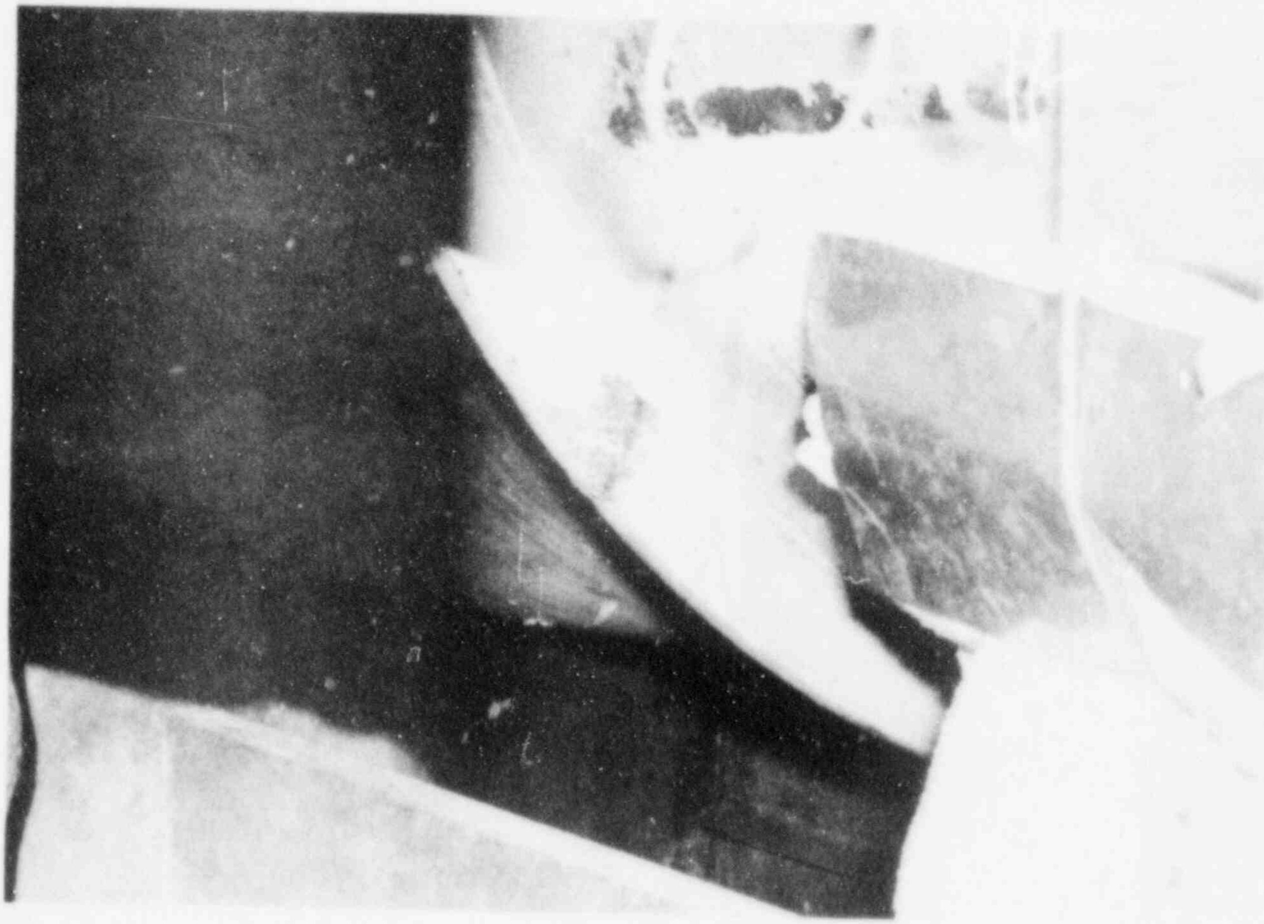


Figure 3.15 Separation of stiffener ring

The middle stiffener ring, next to the rupture, also shows signs of separation of its butt weld.

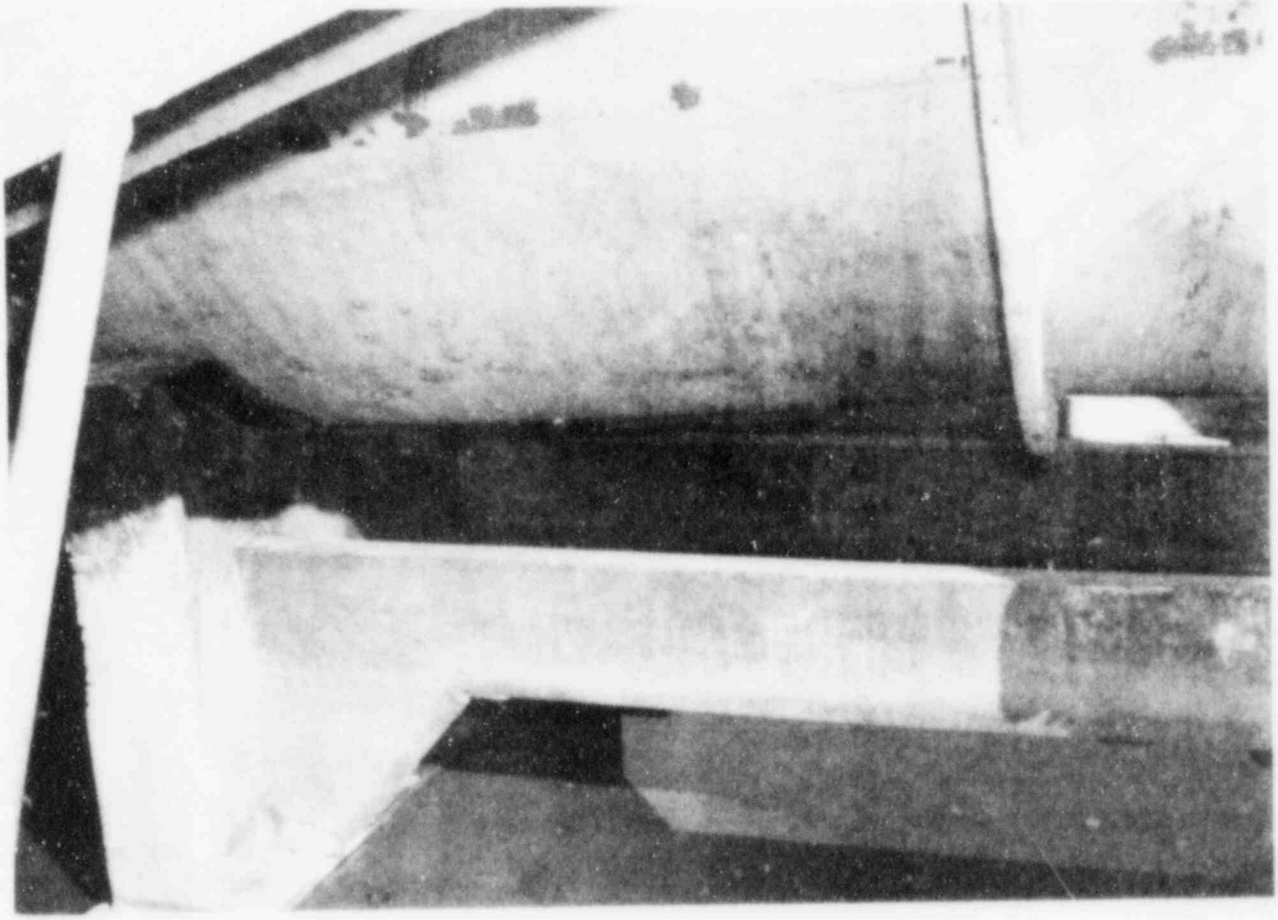
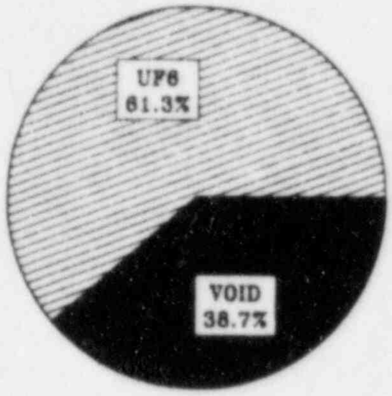


Figure 3.16 Deformation of cylinder wall

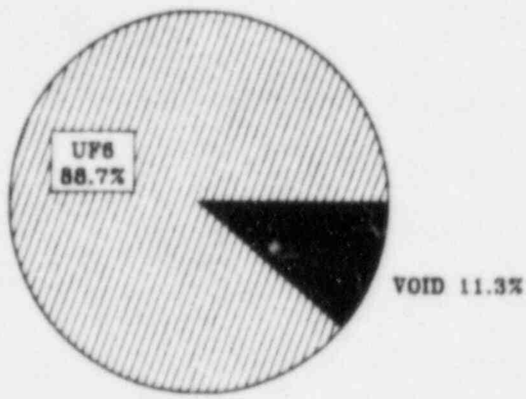
Bulging of the cylinder wall between the stiffener rings is clearly evident.

Figure 3.17

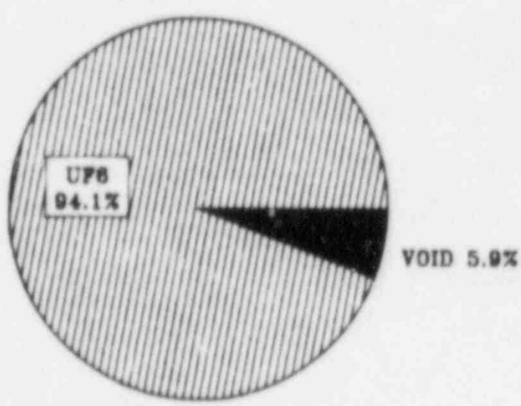
Uranium Hexafluoride Cylinder Model 48Y Normally Filled Contents Weight: 27,560 pounds



SOLID @ 100 F



LIQUID @ 200 F



LIQUID @ 250 F

4 FACTORS CONTRIBUTING TO THE CAUSE OF THE ACCIDENT

The following factors, which are discussed in further detail in Section 5, were identified as primary contributors to the accident. These causes are listed in chronological order, pointing out the primary factors in the order in which they occurred. The individual factors are closely interrelated in many cases. Separating them and ranking them by importance would not only be difficult, it could give the impression that the solution can be approached piecemeal, an approach not consistent with the complexity of the problem. For example, a procedure was not followed; in addition, training in procedures was judged inadequate. How can these two factors be separated and their relative importance judged? The investigation team has not attempted this task.

(1) The cylinder was overfilled because it was not placed fully on the scales.

The fill bay was not designed to accommodate 14-ton cylinders.

The fill bay and associated equipment were not designed to prevent improper positioning of cylinders in the bay so that the cylinder would not be on the scales.

(2) The time required for filling the cylinder was long enough to allow partial solidification of the UF_6, which inhibited product removal from the cylinder.

(3) The precise weight of the cylinder was not readily determinable after it was overfilled.

(4) There was no secondary or alternative way to measure the quantity of material in a cylinder being filled.

(5) Employees violated company procedures when they heated an overfilled cylinder.

Workers, including line management personnel, had not been sufficiently trained in regard to company procedures.

Procedural controls such as checklists or approval points were not used.

(6) Equipment for monitoring or automatically venting cylinders that are being heated was not used.

In summary, the factors can be aggregated into the following causes of the accident:

- The physical equipment and facilities used for filling and weighing UF_6 cylinders were inappropriate for safe use with 14-ton cylinders.

- The training of workers in operating procedures and ensuring the implementation of these procedures were not carried out effectively.

5 FINDINGS AND CONCLUSIONS

5.1 Improper Positioning of Cylinder on Scales

The first event that led to the incident was the improper alignment of the cylinder on the scales in the drain bay. Interviews with workers have not enabled the investigators to determine with surety how the misalignment occurred or the identity of the shift during which it occurred. The worker who first moved the cylinder onto the scales during the day shift on January 3, 1986, was also the worker who was killed during the accident on the subsequent day shift; therefore, no information regarding his activities can be obtained. The chemical operator on the evening shift of January 3 stated that he was unaware of the misalignment as did the midnight shift chemical operator of January 4, who only became aware of the error when he was unable to add more material to the cylinder. He stated that he then noticed that the northeast wheel of the cart was partially off the scales. The chemical operator stated that whereas this one wheel was partially off the scales, the wheel at the opposite end of the axle was fully on the scales. The NRC investigators later observed that the cart was slightly misaligned and showed evidence of having been struck with great force on an earlier occasion. The bent steel plate beside the northeast wheel likely was struck by a vehicle such as a fork truck.

The midnight shift chemical operator also stated that a reason for the close clearance between the wheels and the edge of the scale platform was that the 14-ton cylinder is longer than the more frequently used 10-ton model. He also noted that placement of the cylinder on the cart is critical to ensure that the front end of the cylinder does not contact the filling bay header before the cart is fully on the scales. He stated that it was standard practice to place the edge of the cylinder stiffening ring against the side of the cart in order to afford the maximum available clearance. (The orientation on the cart is critical only for a 14-ton model; the shorter 10-ton model provides more flexibility in regard to cylinder/cart orientation.) Figure 5.1 shows the position of the cart on the scale platform for a properly positioned 14-ton cylinder. The operator stated that the subject cylinder had been located on the cart so that the ring was several inches away from the cart. This decreased the available clearance between the wheels and the edge of the scale platform. This misorientation of the cylinder on the cart inevitably contributed to the cart being off the scales.

The investigators observed that the fill bay and cart are designed in such a way as to require strict reliance on visual observation to ensure that the cart is on the scales. That is, there are no gates or interconnects to ensure that the cart is on the scales before filling begins. Also, the fill bay originally had been designed to accommodate a 10-ton, rather than a 14-ton, cylinder; thus, the clearance available for the 14-ton model was marginal. Employees who had worked at the plant since it had first begun production stated that 14-ton cylinders were not used until many years after the plant opened. Also, a review of licensee records indicated that only about 10% of product cylinders filled are of the 14-ton design; thus, the infrequent use of this model may have contributed to an increased probability of error.

5.2 Extended Interval for Cylinder Filling Resulting in Product Solidification

Cylinder filling began at about 10:00 a.m. on January 3, 1986, and was not completed until approximately 6:00 a.m. on January 4. Cylinders are filled at ambient temperature with liquid UF_6 entering the cylinder at a temperature of about 210°F. Since UF_6 solidifies at a temperature of 147°F, at least some of the product in the cylinder would have solidified during the 20-hour fill interval. When UF_6 changes phase from liquid to solid, it undergoes a considerable decrease in volume. This would have allowed additional liquid UF_6 to be added to the cylinder before it was filled to its volume capacity.

Apparently the cylinder was indeed filled to its volume capacity, since the midnight shift operator stated that he was unable to add any more product into it. Once UF_6 has solidified, its reduced vapor pressure makes withdrawal of excess material by vacuum a long procedure. The later inability of the day shift operator to remove material from the cylinder would suggest that even material at the top of the cylinder had begun to solidify. The subsequent heating of the cylinder with steam would have caused the solidified product to change phase, drastically increase in volume, and ultimately result in the bursting of the cylinder.

5.3 Inability To Determine Cylinder Weight

As a result of an inspection of the scales by a National Bureau of Standards (NBS) engineer and a representative of the scale manufacturer, it is apparent that the scale dial indicator, which reportedly read about 29,500 pounds for the filled cylinder, was at that time indicating the maximum weight reading that the scales were capable of providing, even though the scale dial ranged to 30,000 pounds. The NBS inspection revealed that the dial indicator would not register beyond 29,760 pounds, a weight less than 1% higher than that reported. As previously indicated, the midnight shift operator moved the counterweight on the scales to free the dial indicator so that a drop in weight would register as product was removed. Thus, the weight of the product in the cylinder was likely to have been considerably more than 29,500 pounds, and it is likely that the workers would have been unaware of the considerable overfill weight at the time the cylinder was transferred to the steam chest.

The NBS investigator also noted that moving the counterweight 6 inches to the right to allow a free dial indication at about 28,000 pounds would have compensated for approximately 3,000 pounds. Thus, the cylinder is likely to have been filled to a net weight of approximately 31,000 pounds. It is unclear how much material was removed from the cylinder before it was transferred to the steam chest; however, the net weight was clearly no less than 29,500 pounds, the maximum observable weight on the scales. As previously indicated, at least 31,000 pounds of product would be expected to produce the hydraulic rupture.

Most of the chemical operators who had worked with the scales for many years stated that they had encountered no problems in the use or performance of the scales; however, a few indicated that sometimes the scales would stick and would require a nudge to restore free indicator movement. There is no indication that faulty scales contributed to the cause of the incident. A review of records disclosed that the scales had been inspected and calibrated by a service vendor on September 17, 1985.

Although the zeroing of the scales when an empty cylinder is first moved onto them is not a contributor to the cause of the incident, the NRC investigators noted that it leads to the false assumption that the cylinder is indeed empty. Most cylinders do contain a small residual "heel" of material weighing less than 100 pounds which is not removed from a cylinder when it is emptied. In fact, the cylinder that ruptured contained a 45 pound heel, according to plant records. Thus, the net weight read from the scale indicator as the cylinder is filled excludes the heel weight. Although paperwork accompanying a cylinder records both the original tare and the present tare weight of the cylinder, failure to compensate for an unusually large heel could result in significant undetected cylinder overfill.

5.4 No Redundancy of Measurements

There is no secondary or alternative way to measure the quantity of material in a cylinder being filled. The UF_6 gas is collected in cold traps and is accumulated there as a solid before it is transferred as a liquid to the cylinders at the weigh station. When the UF_6 liquid transfer is made, no means are available to the operator to determine the quantity of liquid drained from the trap. The only information available to the operator is the observed weight of the cylinder contents at the beginning and end of a transfer. These are important contributing factors in that the operator had no way of knowing how much UF_6 had been delivered to the cylinder other than by observing the loading scale. As a result, the operator overfilled the cylinder that eventually ruptured on the basis of erroneously low scale readings caused by the cart wheel being off the scale platform.

5.5 Violation of Licensee's Procedures by Workers

Sequoyah Fuels Corporation Procedure N-280-1, "Uranium Hexafluoride Product Handling and shipping," Revision 6, which was approved by facility management and effective on January 28, 1985, states in two places within the portion of the procedure regarding cylinder filling:

> Note: Do not heat a cylinder which has been overfilled. Evacuate the overfilled cylinder without heating until the maximum net weight is attained. This is necessary to prevent rupture of the cylinder due to hydrostatic pressure.

The assistant shift supervisor stated that he could not remember receiving or being indoctrinated in this procedural requirement and directed that the overfilled cylinder be placed in the steam chest to liquefy the contents so more material could be removed. There is no record of this assistant shift supervisor or his shift having been trained in Procedure N-280-1. Interviews of workers and supervisors alike confirmed that there has been little initial or refresher training in regard to operating procedures. They did state, however, that they were aware of the existence of procedures and had access to procedure manuals located at various locations within the plant.

Procedure N-280-1 provides that cylinder filling must be stopped when the scale reading reaches 100 pounds over the maximum allowable. The cylinder is then to be evacuated to withdraw approximately 100 pounds of material such that the maximum specification capacity is achieved before the cylinder is sent to a steam chest if homogenization is needed. A review of records for cylinders previously filled indicated that cylinders are sometimes still overfilled by about 100 pounds before being heated in the steam chests. Each cylinder is then dispatched to a bay where a sample is obtained and an amount of UF_6 necessary to obtain the specification weight before shipment is evacuated.

A review of the procedures also disclosed that there has been no provision for checklists or other forms of approval points whereby a supervisor might authorize the disposition of a filled cylinder. Operators stated that they themselves were authorized and responsible for moving a filled cylinder to a steam chest for heating before sampling and final weighing.

5.6 Failure in Design of Steam Chests To Enable Cylinder Pressure Relief

The fill valves of cylinders are closed when the cylinders are heated in the steam chests, thus providing no means of pressure relief in an overpressure situation. Only one steam chest--not the one involved in the incident--is supplied with a connection line to the cold traps to enable removal of product contamination such as chromium or molybdenum, but the cylinder is vented to this line only after it has been heated in the chest long enough to ensure that the contents are fully liquefied.

A pressure transducer or relief valve installed at the cylinder valve would have given early warning of an overpressure condition and allow actions to reduce temperature and/or pressure to begin.

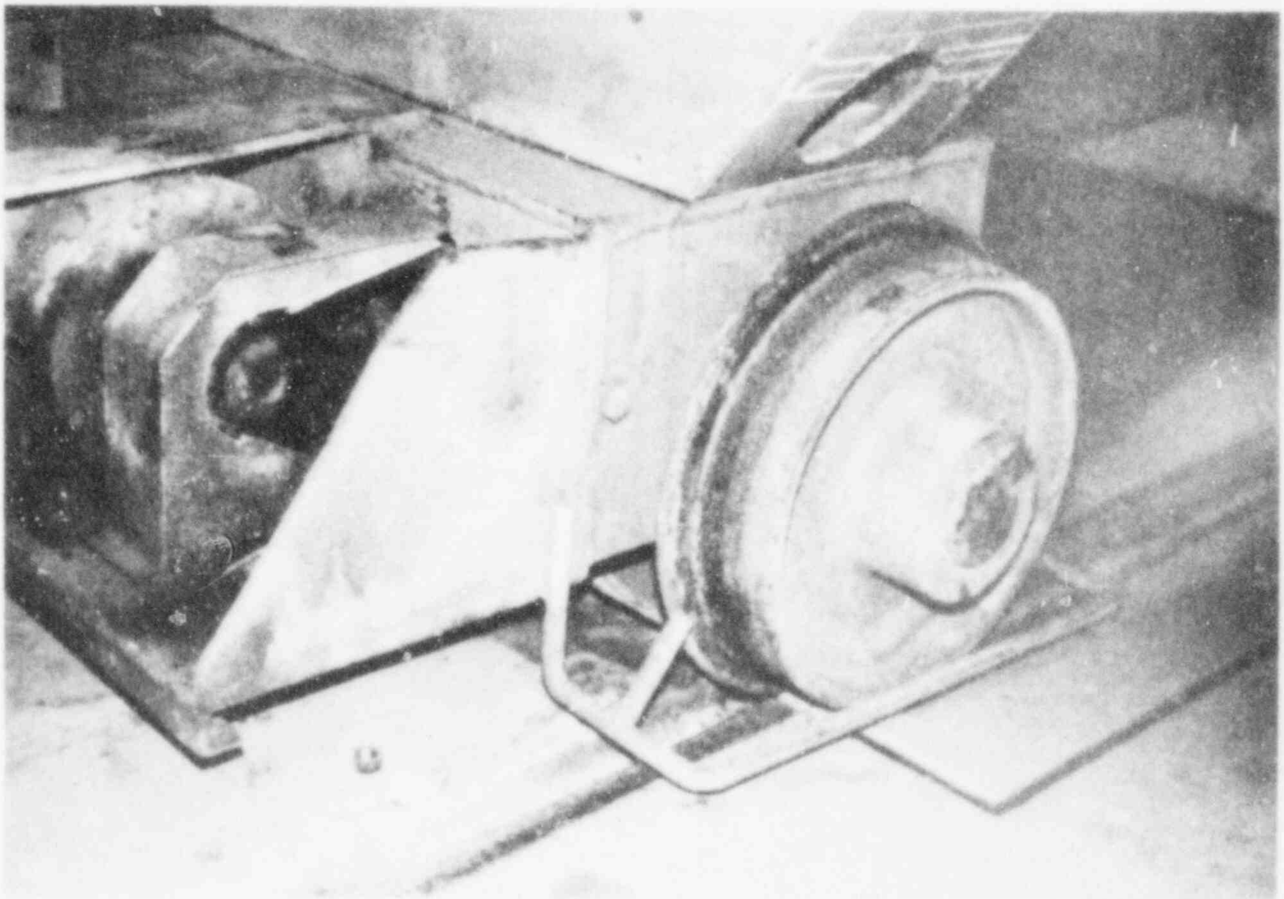


Figure 5.1 Cart wheel alignment

With a 14-ton cylinder placed in its optimum position on the cart and moved as close as possible to the drain station, the rear wheel is less than an inch from the edge of the scale platform.

APPENDICES

APPENDIX A - NBS Report on Scale Testing.

APPENDIX B - Inspection of Process Instrumentation.

APPENDIX C - Sequoyah Facility License.

APPENDIX D - Pertinent Sequoyah Operating Procedures.

APPENDIX A

Report of Investigation at the Kerr-McGee Corporation
Sequoyah Facility, Gore, Oklahoma
January 28-29, 1986
Otto K. Warnlof
National Bureau of Standards

We arrived at the plant at 8:00 a.m. on January 28, 1986. At approximately 9:45 a.m., a group of 16 persons was gathered for a briefing by the plant manager. There were representatives from Kerr-McGee, the Nuclear Regulatory Commission (NRC), Streeter-Richardson Scale Company, Oklahoma Weights and Measures Division, Oklahoma Scale Company, and the National Bureau of Standards (NBS). Individual names were not recorded.

The briefing included health and safety precautions and requirements. A brief description of the method of weighing at the plant and the equipment used was also given. It was stated that this survey was under the direction of the plant manager and Dale Smith, NRC, and a procedure was circulated and briefly discussed. After each individual was issued health and safety clothing, etc., the group gathered at the scale site. The plant manager briefly reviewed the plant weighing operations.

Scale Description

Manufacturer: Howe Richardson
Model: 2800
S/N: 2800
Capacity: 40,000 lbs
Dial Capacity: 30,000 x 30 lbs
Ungraduated tare bar and poise
Platform: 54 x 96" equipped with rails for cart

Scale Condition as Found

Dial Indication: "0"
Tare poise in coincidence with the right most reference mark on beam
Scale Platform: Loaded with cart and empty cylinder

The group then began a visual inspection of the conditions found. The principal participants were representatives of Streeter-Richardson, Oklahoma Scale Co., and NBS. The following conditions and events were noted:

- The forward end of the cylinder (located on the scale) was apparently in contact with some piping and valving that was not a part of the scale.

- A scale serviceman "pushed" on the cylinder to "rock" the scale platform.

- The scale indication advanced to approximately 50 lbs.

- A scale serviceman pushed down on the tare bar and released same and the action of the scale dial indicator appeared normal as it returned to the same equilibrium.

- The fill connection and dust collector were removed from cylinder and the dial indication changed to 30 lbs.

- The two lines were reconnected to the cylinder and the dial indication changed to 60 lbs.

- The floor area above the extension levers that connect the scale main levers to the stillyard rod and dial head consists of open grating. This allows debris to gather on and about these vital components of the weighing system.

- The weighing platform consists of two steel rails on which the product to be weighed is moved and three steel plates. The steel plates are secured with bolts. Of the 25 bolt locations, only 5 bolts were in place, the reamining 20 were missing.

- One of the four bumper bolts which limit the lateral movement of the scale platform was missing.

- There were appurtenances attached to the cart that transports the cylinders which extended beyond the scale platform with the cart on the scale. The clearances beneath these attachments and the work floor were minimal. If any appurtenance attached to this cart did come to rest on the work floor, significant weighing errors could result. However, it was later observed that when the scale was fully loaded these attachments did not come into contact with the work floor.

Conclusions at this Juncture

- The oscillation of the dial indicator seemed normal and free of any friction.

- Small weighing errors (30 lbs - 60 lbs) could result when the weighing operation is accomplished with the lines connected.

- Small weighing errors could also result if the cylinder was touching the piping during a weighing operation.

Recommendations

- Piping should be relocated so, that with the cylinder "scale borne," it could not come in contact with anything surrounding the scale.

- Observations should be made when weighing a full cylinder to make a positive determination of the affect on the weighing result with the hoses connected. If the results are larger than desired for the weighing process, ample instructions should be provided to make certain that, when a final weighing result is obtained, the piping is disconnected.

- Weigh rails and dead rails should be modified to provide a smooth transition of the cart to be weighed "on" and "off" the scale.

- The scale extension levers should be protected from falling debris.

- Some provision should be made to lessen the chance that the cart is not "scale borne" during a weighing operation. This could be in the form of positive stops at the forward portions of the rail, and to require "chocks" to be manually inserted at the trailing end behind the cart wheels.

- If the appurtenances attached to the cart that extend over the work floor are considered necessary, it is recommended that they be raised to provide more assurance that they will not come into contact with the work floor. The personnel conducting the weighing should be instructed that, as part of the weighing operation and before any weighing observation is made, an inspection should be made to positively determine that there is no obstruction and ample clearance between that which is to be weighed and the work floor and any other objects surrounding it.

The investigation continued. The back of the dial cabinet and dial head were removed and an inspection was made of the condition of the dial parts. The following observations were noted with some resultant recommendations.

- The stillyard rod (rod connecting lever system to dial head) was so located that it could come in contact with a cabinet housing bracket. This condition could cause small weighing errors and should be corrected.

- The dash pot (cylinder and piston to "dampen" scale indicator action) was low on oil and should be cleaned and refilled.

- The assembly that protects the dial head from dust has leaked oil over the shelf lever power pivot and the bearing assembly and the linkage that allows the dial head to swivel. This assembly should be serviced. This condition should not have resulted in anything other than small weighing errors. The scale test that followed confirmed this.

- The dial indicator locking mechanism was placed in the "locked" position. The dial indicator came to rest at an indication of 29,490 lbs. The locking mechanism was placed in the "unlocked" position. The tare bar was moved to the limit of its movement to simulate a fully loaded scale condition. The resultant dial indication was 29,760 lbs. This indicated that the stop was not properly adjusted and that, with the the locking mechanism in an "unlocked" position, the maximum travel of the dial indicator is an indication of 29,760 lbs. Thus, with any load in excess of this amount on the scale, the scale indication would not exceed 29,760 lbs. This mechanism must be adjusted so that the indicator will travel freely beyond the graduated portion of the dial and come to the limit of its indication at some position near the center of the ungraduated portion of the dial (between the 30,000 lb indication at the "0" indication). This will indicate to an operator when a load on the scale exceeds 30,000 lbs.

- It was also found that the locking mechanism handle could become "disengaged," thus moving freely without providing the desired action of "locking" of "unlocking." This condition should be corrected and some indication should be provided on the dial cabinet to clearly indicate to an operator the position of the locking mechanism handle when it is in a "locked" position and an "unlocked" position.

- All exterior activity was eliminated and, with the dial indicator at rest indicating 60 lbs, 400 lbs of known test weights were added in 100-lb increments. The results were recorded by the Streeter-Richardson representative. My observation concluded that there was no apparent malfunction.

- The cart and tank were removed from the scale platform and the tare poise moved to a "zero" position. The scale indication was "negative" to a value that could not be determined.

- The tare poise was returned to its marked reference position and a load of 3700 lbs of known test weights was applied to the scale platform. The scale indicated approximately "-10 lbs."

- The load on the scale was adjusted to 3710 lbs to provide a "zero indication." A test was conducted and the results are attached as Appendix A. All observations of the weight indications were made by me and recorded by the Streeter-Richardson representative.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The environmental and maintenance conditions as noted could result in weighing errors. These weighing errors would probably range from "0" to 100 lbs. The investigation did not include a positive determination of a quantifiable weighing error that could result when the load applied was not entirely scale borne. It would require an extensive study to quantify any weighing error that could occur, and any test protocol developed would probably not produce results that could be replicated. It can be positively concluded that when the object to be weighed is not entirely "scale borne" a negative error will result. This can be illustrated by installing a person weigher so that the area immediately adjacent to the platform is on the same plane and level with the platform. Then, apply a known load that is partially "on" and partially "off" the scale platform and observe the results.

The linear travel of the tare poise is approximately 20.375 inches which represents a weight value of 10,000 lbs. Thus, one inch of travel is 491 lbs (rounded to the nearest pound); three inches, 1472 lbs; six inches, 2945 lbs. Therefore, if an operator moved the poise on the tare bar to the right a distance of three inches, the dial indicator would indicate a quantity that is approximately 1472 lbs less than the weight value indicated prior to the poise movement.

Conclusions

It was reported that during the initial weighing process the cart and cylinder were not wholly scale borne. When this condition was corrected, the resultant scale indication was higher than the load was intended and could possibly have "bottomed out" at the previously mentioned value of 29,760 lbs. It was also reported that the operator moved the poise on the tare bar to determine if the scale indicator oscillated freely. It seems that it was determined that the cylinder was in an overfill condition and that some product had to be removed. It is not clear that a positive determination of the amount of overfill was determined, and it is highly unlikely that the amount could be determined correctly. It seems evident that there was some operator error, and this situation was enhanced by the fact that the scale indicator could not travel freely beyond 29,760 lbs and did, in fact, "bottom out" at that indication.

SHORT TERM RECOMMENDATIONS

- All of the previous conditions noted, to be corrected by and under the direction of a qualified scale mechanic. In addition, the tare poise and beam should be serviced so that the tare poise moves freely on the tare beam.

- If the scale mechanic makes any changes that in his/her opinion would affect the scale accuracy, a retest with known standards should be made. The minimum test that should be conducted after servicing is the application of the two test weight cylinders of 4503 lbs and 25,509 lbs. The test of the reference scale and these weights made the next day were sufficient to determine that these weights are sufficiently accurate to determine the performance of the scale to within ± 0.1 percent (1/1000).

- The scale should be adjusted so that, with no load on the scale platform and the tare poise at a "zero" position (extreme left), the scale dial indicator will indicate "0." Thus, when the cart and empty cylinder are placed on the scale, the dial indicator will indicate the weight of these two components. This will provide the weigher with a level of confidence that the scale performance is normal. The scale operator can then move the tare poise to the right until the scale dial indicator is in coincidence with the "0" graduation. The operator can then make the connections to the cylinder necessary to complete the filling process. After these connections are made, the operator can note any change in the scale indication and complete the filling operation providing the change is considered negligible. When the cylinder is filled to the desired amount, the hoses can be disconnected and the weight indication observed and noted.

- It was observed that there are weight values and other notations on and about the dial face and housing. It would seem that a "noteboard" could be located near the dial head on which properly instructed weighers could make notations concerning weighing operations or conditions. This would aid in eliminating any problems that develop and may not be readily apparent when work shift personnel changes are made.

LONG-TERM RECOMMENDATIONS

The scale dial indicator should be replaced with an electronic digital indicator. This will require a strain gage load cell to be mounted in the stillyard rod. There are electronic digital indicators available with a variety of operating characteristics and features. Set points for different weight values can be "input" and, when these points are reached or exceeded, an audible and/or visual signal can be produced. Other operating features such as "keyboard tare," push-button tare," and printers are also available. This will eliminate the problems caused by the tare poise position, the dial mechanism maintenance, the ambiguity of the weight results caused by the value of the graduated intervals of 30 pounds, and the indicator travel.

Of particular concern in obtaining an appropriate digital indicator, is the "hostile" environment in which it must operate. These hostile environmental conditions include but are not limited to electromagnetic interference (conducted and radiated) caused by communication equipment such as "walkie-talkies" and the operation of electromechanical equipment such as motors, etc. Evidence should be provided by the supplier that the indicator is suitably protected so that it will perform correctly in this environment.

Another concern is the affect on performance caused by temperature and humidity variations. The temperature and humidity ranges that exist should be quantified so that the equipment supplier can provide equipment that can perform properly under the conditions specified.

A visual examination of the weighing element, that is, the levers, pivots, and bearings located beneath the work floor, was not made. From the results of the test made on the scale, it seems that they are sufficient, and with proper maintenance can continue to be utilized.

RECOMMENDED SCALE INDICATOR -- GENERAL DESCRIPTION

Capacity: 40,000 lbs
Value of the Scale Division (d): 10 lbs
Number of Scale Divisions (n): 4000

The tolerances in NBS Handbook 44 for such a device are as follows:

Test Load	Acceptance Tolerance	Maintenance Tolerance
0 - 5,000 lbs	± 5 lbs (1/2 d)	± 10 lbs (1 d)
5,010 - 20,000 lbs	± 10 lbs (1 d)	± 20 lbs (2 d)
20,010 - 40,000 lbs	± 15 lbs (1 1/2 d)	± 30 lbs (3 d)

Results of Test of Control Scale and Test Weights

A test was conducted of the control scale and test weights described as follows:

Control Scale -

Manufacturer: Fairbanks
Serial Number: 81041
Capacity: 40,000 pounds
Main Poise: 40,000 x 1000 pounds
Fractional Poise: 990 x 10 pounds
Subfractional Poise: 9 x 1 pound
Platform Dimensions: 6 x 14 feet
Butt Multiple: 200:1

Balance Indicator -

Manufacturer: Fairbanks
Model: 91320
Serial Number: (?) D 38562

Two Cylindrical Test Weights Marked:

4,503 pounds
25,509 pounds

Conditions Noted

- The beam notches were cleaned prior to test. The accumulated debris in the notches were not considered sufficient to cause weighing errors in excess of two pounds. The main poise did not "pull" into the notches correctly; the circular rollers on which the poise travels seemed to have a flat space. The subfractional poise did not come to rest properly and the index of the indicator was ambiguous. It is recommended that the entire poise assembly be serviced.

- The change in weight indications with repeated opening and closing of the trig loop was $\pm$ one-half pound.

- The change in weight indications with repeated "seating" of the main poise under a constant load on the platform was $\pm$ two pounds.

There was some debris collected between the scale platform and the pit wall that could cause a weighing error. The test conducted on January 28, 1986, was with the scale in that condition. This debris was cleared before the test conducted on January 29, 1986.

Test of Weights

1. Cart placed on platform with the left end wheels of cart over Section No. 1. (Left end of scale platform.)
   Scale Indication: 4352 lbs

2. Cart moved so that it was located as nearly as possible at the center of the platform.
   Scale Indication: 4352 lbs

3. Cart moved to locate the right end wheels of cart over Section No. 2. (Right end of scale platform.)
   Scale Indication: 4352 lbs

4. Cart removed from scale platform.
   Scale Indication: "0"

5. Conclusion: There was no apparent change in the weight indication of the cart at any location on the scale platform.

6. The cart was placed on the scale and located at the center of the platform. The scale indication was adjusted to a "0" balance indication.

7. The cart was removed from the scale and loaded with the weight marked 4503 pounds and relocated on the scale platform at the "centered" position.
   Scale Indication: 4506 lbs

8. The cart and weight was removed from the scale and returned to the same location.
   Scale Indication: 4505 lbs

9. The procedure in 7 above was repeated.
   Scale Indication: 4505 lbs

10. Cart and weight removed from scale.

11. Conclusions: The most recent test conducted on the scale produced results at a 4000-lb test load positioned at various locations on the scale platform as follows: Section No. 1 - 4002 lbs, Center - 4001.5 lbs, Section No. 2 - 4004 lbs. A test load of nine pounds produced an indication of 10 pounds with the use of the subfractional poise.

It was also noted that the change in weight indication resulting from opening and closing the beam arresting mechanism was ± 0.5 pounds.

Thus, the accumulated error of +1.5 pounds at a test load of 4000 pounds centered on the scale platform and the equilibrium change of 0.5 pounds resulting from opening and closing the beam arresting mechanism indicates that the value of the test weight cylinder is within ± one pound.

This evaluation was not intended as a calibration of the test weight cylinder at a value of 4503 pounds, but rather to determine the indication of the scale with the application of the test weight cylinder. An analysis of these data seemed to indicate that the value of the test weight cylinder as 4503 pounds can be utilized for testing the scales used to weigh the cylinder to an accuracy of ± 0.05 percent (1/2000). However, since the scales used to weigh cylinders have graduated intervals of 30 pounds, it would seem more appropriate that the value of the test weight cylinder be established at a value that is consistent with a scale division, e.g., 4500 pounds.

12. The cart was loaded with the weight marked 25,509 lbs and placed on the scale at the center of the platform..
    Scale Indication: 25,508.5 lbs

13. The cart was removed from and returned to the scale at the same location.
    Scale Indication: 25,509 lbs

14. The cart was moved approximately 13 inches to the left (toward Section No. 1).
    Scale Indication: 25,509.5 lbs

15. The cart was removed from the scale, the test weight cylinder removed, and the empty cart returned to the scale at the center of the platform. The scale was adjusted to a "0" balance indication.

16. Conclusion: An analysis of the test results of this scale and the results of 12, 13, and 14 above are essentially the same as given in 11 above. The same consideration of establishing a value of the test weight that is consistent with a scale division of the scales used to weigh the cylinders is also applicable, that is, 25,500 lbs with a 30-lb scale division or 25,510 lbs with the recommended 10-lb divisions.

Operating Scale - Test Report
January 28, 1986

Test[1] Weights Applied (lb)	Load Position	Scale Indication[2] (lb)	Error (lb)
0	0	0	Balance
2,000	Sec. #2	0	0
4,000	Sec. #2	0	0
6,000	Sec. #2	0	0
8,000	Sec. #2	0	0
8,000	Sec. #1	7,970	-30
8,000	Sec. #1		
2,000	Sec. #2	9,975	-25
8,000	Sec. #1		
4,000	Sec. #2	11,985	-15
8,000	Sec. #1		
6,000	Sec. #2	13,995	- 5
8,000	Sec. #1		
8,000	Sec. #2	16,005	+ 5
8,000	Sec. #1		
7,000	Sec. #2	15,000	0
18,000	Dist.	18,015	+15
20,000	Dist.	20,020	+20
22,000	Dist.	22,010	+10
24,000	Dist.	24,000	0
25,000	Dist.	25,020	+20
26,000	Dist.	26,010	+10
27,000	Dist.	27,000	0
28,000	Dist.	28,000	0
28,300	Dist.	28,305	+ 5
29,000	Dist.	28,995	- 5
29,100	Dist.	29,100	0
29,200	Dist.	29,190	-10
29,300	Dist.	29,290	-10
29,400	Dist.	29,385	-15
29,500	Dist.	29,480	-20

[1]The initial application of 3710 lb to provide a scale indication of "0" was disregarded.
[2]Observation to the nearest 5 lb.

Test[1] Weights Applied (lb)	Load Position	Scale Indication[2] (lb)	Error (lb)
29,600	Dist.	29,580	-20
29,700	Dist.	29,680	-20
29,750	Dist.	29,730	-20
29,740	Dist.	29,720	-20
29,760	Dist.	29,730	-30

At this position, the scale indication "bottomed out" and the indicator would not travel beyond this indication.

29,810	Dist.	29,730	-80

At this point (1:45 p.m.), the test was discontinued and the group broke for lunch. On return from lunch, the test load was decreased to 24,000 lb and the test continued. S-R rep no longer present. OBS by OKW.

24,000	Dist.	24,045	+45
22,000	Dist.	22,035	+35
20,000	Dist.	22,030	+30
18,000	Dist.	18,030	+30
16,000	Dist.	16,030	+30
14,000	Dist.	14,010	+10
12,000	Dist.	12,005	+ 5
10,000	Dist.	10,005	+ 5
8,000	Dist.	8,000	0
6,000	Dist.	6,000	0
4,000	Dist.	4,005	+ 5
2,000	Dist.	2,020	+20
0	0	20	+20

[1]The initial application of 3710 lb to provide a scale indication of "0" disregarded.
[2]Observation to the nearest 5 lb.

Control Scale - Test Report

January 28, 1986 (2:30 - 6:00 p.m.)

Test[1] Weights Applied (lb)	Load Position	Scale Indication[2] (lb)	Error (lb)
0	0	0	Balance
2	Dist.	SR	Right Edge[2]
-2	Dist.	SR	Left Edge[2]
0	0	0	Balance
4,000	Sec. #1	4,002	+ 2
8,000	Sec. #1	7,997	- 3
10,000	Sec. #1	7,997	. - 3
0	0	-0.25	Bal. Change
0	0	0	Balance
4,000	Center	4,003	+ 3
8,000	Center	7,998.5	- 1.5
10,000	Center	10,000	0
0	0	0	Bal. Change
4,000	Sec. #2	4,003	+ 3
8,000	Sec. #2	7,999.5	- 0.5
10,000	Sec. #2	10,002	+ 2
10,000 4,000	Sec. #2 Center	14,002.5	+ 2.5
10,000 8,000	Sec. #2 Center	18,001.5	+ 1.5
10,000 10,000	Sec. #2 Center	20,003.5	+ 3.5
10,000 10,000 4,000	Sec. #2 Center Sec. #1	23,994	- 6
10,000 10,000 8,000	Sec. #2 Center Sec. #1	27,993.5	- 6.5
30,000	Dist.	29,987.5	- 2.5
8,000	Sec. #2	8,000.5	+ 0.5
0	0	1.5	Bal. Change

[1]Observations to the nearest one-half pound.

[2]Four pounds changes the equilibrium of the balance indicator from an equilibrium at the left edge of the central target area to an equilibrium at the right edge of the central target area.

Control Scale - Test Report

January 29, 1986 (9:00 a.m. - 12:30 p.m.)

Test Weights Applied (lb)	Load Position	Scale Indication[1] (lb)	Error (lb)
0	0	0	Balance
9	Dist.	10	+ 1
990	Dist.	987	- 3
1,000	Dist.	996.5	- 3.5
0	0	0	Bal. Change
4,000	Sec. #1	4,002	+ 2
5,000	Sec. #1	5,001.5	+ 1.5
8,000	Sec. #1	8,000.5	+ 0.5
10,000	Sec. #1	10,001	+ 1
0	0	+ 1	Bal. Change
0	0	0	Balance
4,000	Center	4,001.5	+ 1.5
8,000	Center	7,999.5	- 0.5
10,000	Center	10,001	+ 1
0	0	+ 0.5	Bal. Change
0	0	0	Balance
4,000	Sec. #2	4,004	+ 4
8,000	Sec. #2	8,000.5	+ 0.5
10,000	Sec. #2	10,001.5	+ 1.5
10,000 4,000	Sec. #2 Center	14,003	+ 3
10,000 8,000	Sec. #2 Center	18,002	+ 2
10,000 10,000	Sec. #2 Center	20,004.5	+ 4.5
10,000 10,000 1,000	Sec. #2 Center Sec. #1	20,999	- 1
10,000 10,000 4,000	Sec. #2 Center Sec. #1	23,995.5	- 4.5

[1]Observations to the nearest one-half pound.
[2]Four pounds changes the equilibrium of the balance indicator from an equilibrium at the left edge of the central target area to an equilibrium at the right edge of the central target area.

Control Scale - Test Report (Continued)

January 29, 1986 (9:00 a.m. - 12:30 p.m.)

Test Weights Applied (lb)	Load Position	Scale Indication[1] (lb)	Error (lb)
10,000	Sec. #2		
10,000	Center	27,995	- 5.0
8,000	Sec. #1		
30,000	Dist.	29,998	- 2.0
31,000	Dist.	31,001	+ 1.0
32,000	Dist.	31,994.5	- 5.5
32,000	Dist.	4	SR
10,000	Sec. #2		
10,000	Center	24,999.5	- 0.5
5,000	Sec. #1		
0	0	- 0.5	Bal. Change

[1]Observations to the nearest one-half pound.

[2]Four pounds changes the equilibrium of the balance indicator from an equilibrium at the left edge of the central target area to an equilibrium at the right edge of the central target area.

APPENDIX B

PROCESS AND INSTRUMENTATION CONTROL INVESTIGATION

An inspection was made of the areas of the cold trap room and steam chests to verify if a failure in a process control or instrumentation system was a contributing factor in the failure to detect the UF_6 cylinder being overfilled by plant employees.

The NRC reviewed the following Piping and Instrumentation Diagrams (P&ID's):

1. 270-M-103 Rev. 13 - Primary Fluorination Cold Traps

2. 280-M-101 Rev. 2 - Product Shipping Flow Sheet

3. 280-M-102 Rev. 7 - Product Shipping Flow Sheet.

The P&ID's were reviewed and the NRC verified that the system reflected the "as built" design of the drawings. The NRC observed that no process control systems are involved in the loading of the UF_6 cylinders on the scales or the filling of the UF_6 cylinders. There are no automatic shutoff values or alarms associated with the filling of the UF_6 cylinders, locally or in the control room.

It was also observed that there is no process control or instrumentation associated with the steam chests. The heating of the UF_6 cylinders inside the steam chests is done by steam, essentially at atmospheric pressure. System design indicates that no high pressures could be introduced in the steam chests which could cause a UF_6 cylinder to rupture without other contributing factors.

The NRC reviewed P&ID's to verify if pressure indicators or level indicators were installed on the primary and secondary cold traps to indicate the levels being introduced into the UF_6 cylinders. The drawings did not identify any means of measuring levels in the cold traps. The NRC investigator "walked down" the cold traps to ascertain if level indicating instruments were identified on the cold traps. The NRC talked to plant employees to clarify if level indicators or pressure gauges were used to indicate levels in the cold traps. The plant employees stated there was no instrumentation on the cold traps to indicate levels. A plant employee stated that the primary and secondary cold traps are installed in series. If the primary traps become overfilled or solidfy, the overfill is carried over to the secondary cold traps or the back pressure in the system will cause the process to be shut down.

The NRC also interviewed a shift supervisor concerning the use of the load cells on the cold traps. The shift supervisor stated that the load cells were not used to monitor the levels in the cold traps. He stated that filling of the cold traps is mainly controlled on a time basis. The shift supervisor stated that times for filling cold traps are calculated with a high degree of accuracy. He further stated that the time required to fill cold traps is never extended because of low levels in the traps. According to the shift supervisor, the time could be shortened, but never extended. It was stated that procedures were available. The supervisor stated that the load cells were very seldom used for the purpose of level indication. It was stated that operators experience and the filling times are all that is used to control cold trap levels and that operators are confident in the accuracy of these controls.

In conclusion, it appears that no instrumentation is used to monitor UF_6 levels in the cold traps. The instrumentation which is supplied with the system is seldom used. The NRC could not verify if a preventative maintenance or calibration probram is being implemented for these instruments. The reliability of the instruments, based on the limited field investigation by NRC, remains indeterminate. Logs used to time the process were not available for inspection by NRC. There is no way to determine of the instruments (load cells) have departed from normal performance. The NRC inspector was not able to obtain any information about the standards (ANS-15.18-1975) used at this plant.

Also during this inspection, the NRC reviewed the latest documentation pertaining to the calibration, inspection and adjustment of the scales used to weigh the UF_6 cylinders. The document indicated the following scales had last been inspected on September 17, 1985:

Model No.	Serial No.
Howe 2800-S	71-02503
Howe 2800-S	71-02504

In conclusion, the NRC did not identify any process control systems or instrumentation failures which may have directly or indirectly contributed to the failure of the plant employees to detect the UF_6 cylinder being overfilled.

The process of filling the cylinders is strictly a manual process. The control room maintains radio contact, but does not monitor or contribute to the filling of the UF_6 cylinder.

APPENDIX C

SEP 20 1985

SEP 27 1985

FCUP:DAC
40-8027
SUB-1010

Sequoyah Fuels Corporation
ATTN: Dr. John C. Stauter, Director
Nuclear Licensing
Kerr-McGee Center
Oklahoma City, OK 73125

Gentlemen:

Enclosed is Source Material License No. SUB-1010 as renewed. This license is renewed for a 5-year term, expiring September 30, 1990, and contains additional conditions which were discussed between your Dr. J. C. Stauter and Dr. D. A. Cool of my staff. A copy of the Safety Evaluation Report prepared in support of this renewal action is enclosed for your information.

You are hereby advised that any requests for amendment to this license should be submitted in the form of replacement or additional pages to the License Conditions Section and, if necessary, to the Demonstration Section with the changes or new items clearly identified.

This renewal is issued following preparation of an Environmental Assessment (NUREG-1157) related to the continued operation of your facility. Based upon the findings in the Environmental Assessment, a Finding of No Significant Impact has been prepared, approved pursuant to 10 CFR Part 51, and published in the Federal Register. A copy of the Finding of No Significant Impact and the supporting NUREG-1157 are enclosed.

Please note that as a condition of this license, Sequoyah Fuels Corporation is required to prepare and submit changes to the decommissioning plan which provide for permanent disposal of all solid wastes generated by the facility. In particular, the decommissioning plan must address the disposal of raffinate sludge which is currently being stored onsite. The plan shall include an estimate of the costs involved and the financial arrangements that have been or will be made to assure that adequate funds will be available to cover the costs of disposal. If, at some time after the approval of the disposal plan, you determine that there is an alternative disposal method for these materials, an application may be made for NRC approval of the new alternative.

As part of the license renewal review, the staff has reviewed the changes in the Radiological Contingency Plan submitted by letter dated August 24, 1984. The staff finds that these changes do not decrease the response effectiveness of the Plan and are appropriate for the continued implementation of an effective response capability.

If you have any questions regarding this licensing action, please feel free to call me or Dr. Donald A. Cool of my staff at 301-427-4510.

Sincerely,

Original signed by:
W. T. Crow

W. T. Crow, Acting Chief
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety, NMSS

Enclosures: As stated

MATERIALS LICENSE

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10 Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. Sequoyah Fuels Corporation	3. License number SUB-1010
2. Kerr-McGee Center Oklahoma City, Oklahoma 73125	4. Expiration date September 30, 1990
	5. Docket or Reference No. 40-8027

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
6. Material Source	7. Form Any Form	8. Quantity 20 million MTU

9. Authorized Use: For use in accordance with the statements, representations, and conditions contained in Chapters 1 through 8 of the license renewal application dated August 23, 1985.

10. Authorized Place of Use: The licensee's existing facilities at Gore, Oklahoma.

11. Within 6 months of the issuance of this license, the licensee shall prepare and submit to the Uranium Fuel Licensing Branch the following reports. These reports shall contain sufficient detail and analysis to allow an independent review and shall contain licensee commitments for the actions described.

    a. A report detailing handling procedures for product cylinders containing liquid UF_6. The report shall include a detailed analysis of each step in the handling of hot cylinders and identify the possible scenerios which could result in cylinder rupture. The report shall also provide an assessment of the modifications and actions which could be taken to reduce the potential for a UF_6 release and justify the procedures being used.

    b. A report detailing measures and actions to mitigate the effects of a UF_6 release. The report shall deal with the potential release of material within the facility and outside of the facility.

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
SUB-1010

Docket or Reference number
40-8027

12. Within 3 months of the renewal of this license, the licensee shall reevaluate the existing groundwater conditions in the area of the treated raffinate storage ponds and prepare and submit for NRC review a report which describes these conditions and either justifies the current monitoring program or proposes a new program for groundwater monitoring.

13. Within 3 months of the renewal of this license, the licensee shall submit to NRC for review and approval a supplemental vegetation monitoring program to provide additional information for the radiological assessment on the ingestion pathway. The vegetation monitoring program shall include the sampling of food crops in the general area. The vegetation samples collected shall be analyzed for uranium, Ra-226, and Th-230. The licensee shall be able to use these data to assess the radiological impact to any member of the general public exposed from the ingestion pathway. A report of the findings shall be submitted to NRC for review. The program shall be initiated on the next growing season upon approval by NRC.

14. The licensee shall investigate and verify that the elevated uranium and nitrate concentrations found in Well FTP-2A are not the result of the liquid seepage from Ponds 3 or 4. A report of the investigation shall be submitted to NRC within 6 months from the date of renewal of the license.

15. The licensee shall propose an appropriate surface water monitoring program to determine the total quantity of uranium discharged to the environs from the runoff drainage ditches which are not included in the NPDES permit. The proposed program shall be submitted to NRC for review and approval within 3 months from the date of renewal of the license.

16. The licensee shall investigate the cause of some of the elevated uranium concentrations in the runoffs identified in Condition 15. Within 3 months from the date of renewal of the license, a report of the investigation shall be submitted to NRC. The report shall describe what mitigating measures, if any, were taken to eliminate the source(s).

17. The licensee shall conduct a comprehensive soil/sediment radiological survey to determine the extent of uranium accumulation along the length of the effluent stream (001), at the confluence, upstream and downstream of the Illinois River, and along the intermittent runoff areas identified in Condition 14. The results of this survey and any recommendations for mitigation shall be reported to NRC within 12 months from the date of the renewal of the license.

18. The licensee shall submit for NRC review and approval the plan and criteria for decommissioning Pond No. 2 upon the completion of sludge removal from Pond No. 2.

19. The licensee shall maintain a spare pond having capacity equal to or greater than Pond No. 5, unless the licensee's deep well injection plan has been approved.

20. At the end of plant life, the licensee shall decontaminate and decommission the facility so that it can be released for unrestricted use.

License number SUB-1010

MATERIALS LICENSE
SUPPLEMENTARY SHEET

Docket or Reference number 40-8027

21. The licensee shall, by October 1, 1986, prepare and submit changes to the decommissioning plan which provide for the permanent disposal of all solid wastes generated by the facility. The plan shall include an estimate of the costs involved in disposing of these wastes and the financial arrangements that have been or will be made to assure that adequate funds will be available to cover these costs at the time of disposal.

22. The licensee shall implement, maintain, and execute the response measures of his Radiological Contingency Plan submitted to the Commission on March 11, 1982. The licensee shall also maintain implementing procedures for his Radiological Contingency Plan as necessary to implement the Plan. The licensee shall make no change in his Radiological Contingency Plan that would decrease the response effectiveness of the Plan without prior Commission approval as evidenced by a license amendment. The licensee may make changes to his Radiological Contingency Plan without prior Commission approval if the changes do not decrease the response effectiveness of the Plan. The licensee shall maintain records of changes that are made to the Plan without prior approval for a period of 2 years from the date of the change and shall furnish the Chief, Uranium Fuel Licensing Branch, Division of Fuel Cycle and Material Safety, NMSS, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555, and the appropriate NRC Regional Office specified in Appendix D of 10 CFR Part 20, a report containing a description of each change within 6 months after the change is made.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Date: SEP 20 1985

By: Original signed by: W. T. Crow
Division of Fuel Cycle and
Material Safety, NMSS
Washington, D.C. 20555

SEP 20 1985

Safety Evaluation Report

By The

Division of Fuel Cycle and Material Safety

Related to the

NRC Source Material License Renewal

for

Sequoyah Fuels Corporation

UF_6 Conversion Plant

Gore, Oklahoma

Docket Number 40-8027

License Number SUB-1010

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I. INTRODUCTION

A. General

The Sequoyah Facility of Sequoyah Fuels Corporation functions under Source Material License No. SUB-1010 to refine uranium from uranium ore concentrates and convert this uranium to uranium hexafluoride (UF_6) for use in Department of Energy enrichment plants. Refinement and conversion is accomplished by a wet solvent extraction process, oxidation to uranium dioxide (UO_2), and fluorination to produce the ultimate UF_6 product.

B. Location Description

The Sequoyah Facility is located 2½ miles southeast of Gore, Oklahoma, about 40 miles west of Fort Smith, Arkansas, and 150 miles east of Oklahoma City, Oklahoma. Figure 1 shows the geographical location of the plant site, which is bounded by the Illinois and Arkansas Rivers on the west, U.S. Highway 64 on the south, Interstate Highway 40 on the south, and the eastern section line of Section 22 (approximately 2 miles east of the Arkansas River) on the east. Operations are conducted within a fenced restricted area accessible from U.S. Highway 10.

C. License History

Source Material License No. SUB-1010, authorizing storage only of uranium ore concentrates, was originally issued October 14, 1969. The license was revised on February 20, 1970, to authorize use of the material for production of UF_6. The license was last renewed on October 7, 1977, and has been amended 28 times. A listing of license amendments is given in Table 1. The license was scheduled to expire on October 31, 1982, but has remained in effect in accordance with the timely renewal provisions of 10 CFR 40.43(b) by virtue of the timely application for renewal submitted by letter dated September 24, 1982.

II. AUTHORIZED ACTIVITIES

A. General Summary

The activities being assessed by this safety evaluation are related to the possession and use of natural uranium for the production of UF_6 from uranium ore concentrates. These activities include control laboratory procedures; treatment, storage, and disposal of process and contaminated waste materials; and storage of natural and depleted UF_6.

FIGURE 1 - GEOGRAPHICAL LOCATION OF SEQUOYAH FUELS CORPORATION FACILITY

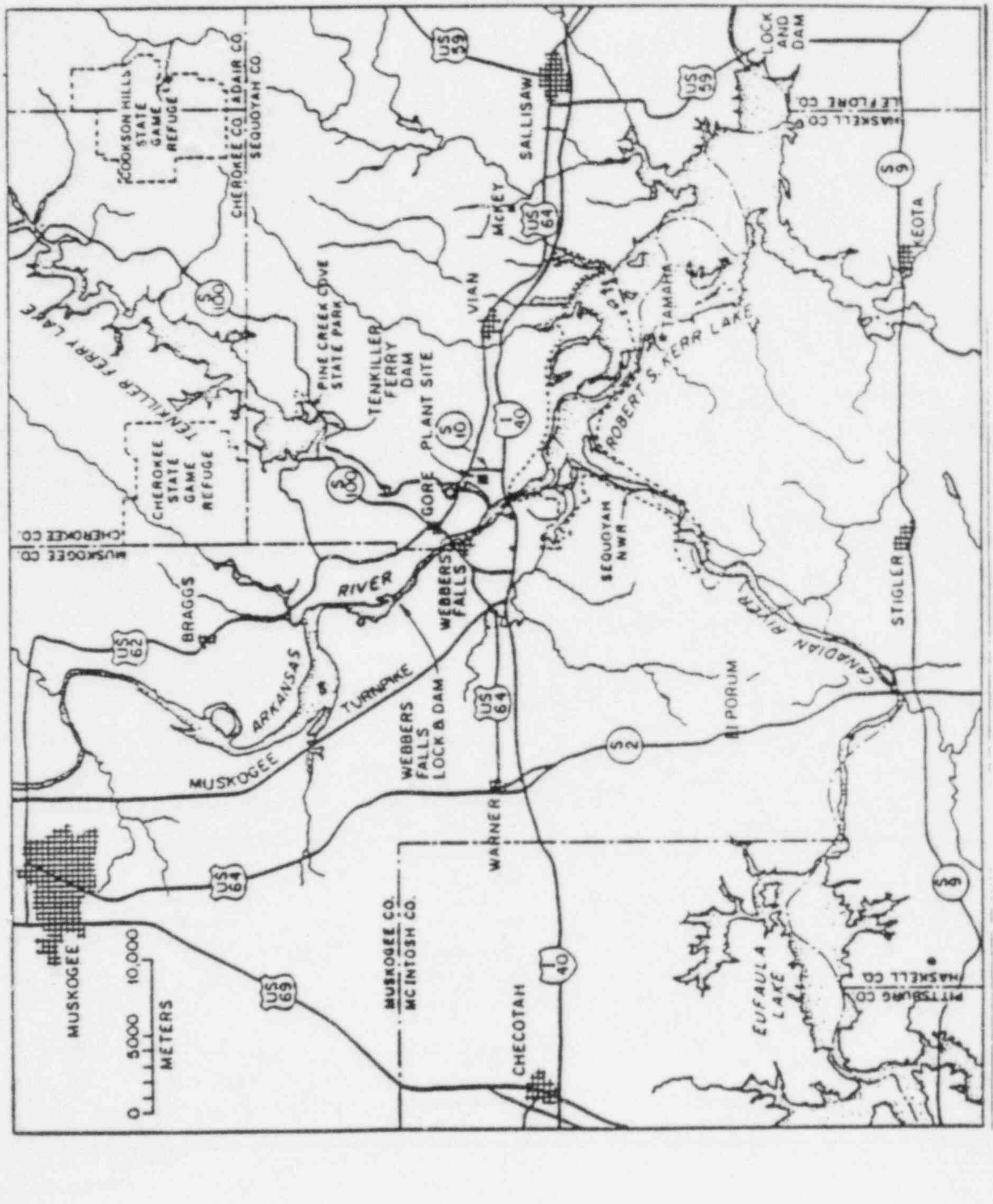

TABLE 1 - LICENSE AMENDMENTS TO SUB-1010

DATE	DESCRIPTION
July 7, 1978	Amendment #1 authorizes continued test distribution of treated raffinate over existing 160 acres of KM owned land during 1978 growing season.
July 7, 1978	Amendment #2 authorizes construction and use of a new liquid waste Pond No. 3.
March 26, 1979	Amendment #3 includes decommissioning plans and financial surety (Condition No. 16).
April 16, 1979	Amendment #4 authorizing test distribution of treated raffinate over 270 acres of KM owned land during the 1979 growing season, the continuation of test distribution of treated raffinate over the existing 160 acres of KM owned land during the 1979 growing season, and the food chain testing of raffinate fertilizer pasture.
July 12, 1979	Amendment #5 authorizing reduction in sampling frequency of 26 sampling stations.
July 20, 1979	Amendment #6 authorizing remodeling of Pond No. 1 and the installation of Clarifier-A.
September 14, 1979	Amendment #7 authorizing the construction and use of a new liquid waste Pond No. 4.
January 10, 1980	Amendment #8 exempting treated raffinate storage ponds from the spare pond requirements of Condition No. 13. Amendment No. 8 to expire on September 1, 1980.
January 28, 1980	Amendment #9 Order to Modify License - set conditions to limit radioactivity in effluents in compliance with 40 CFR 190.
April 28, 1980	Amendment #10 changes Conditions 9 and 12 to remove inconsistencies in the license.

TABLE 1 - CONTINUED

DATE	DESCRIPTION
June 17, 1980	Amendment #11 authorizes use, on a permanent basis, of treated raffinate fertilizer on KM owned land.
February 24, 1981	Amendment #12 authorizes the use of hay grown on the test site for non-forage use, such as mulching, provided the hay contains no more than 1.0 pCi/gm Ra 226, 0.25 pCi/gm Th 230, or 2.5 μgm/gm uranium.
July 21, 1981	Amendment #13 authorizing use of treated raffinate for fertilizer on KM owned land in Haskell County, Oklahoma (Choctaw mine property).
March 25, 1982	Amendment #14 incorporates the Radiological Contingency Plan by adding Condition 21.
April 2, 1982	Amendment #15 authorizes use of treated raffinate for fertilizer on KM owned land in Muskogee County, Oklahoma (Rabbit Hill area).
May 3, 1982	Amendment #16 exempts the treated raffinate storage ponds from the spare ponding requirement of Condition 13 until September 1, 1982.
June 30, 1982	Amendment #17 authorizes use of treated raffinate for fertilizer and release of crops which are not used directly as human food under 13 specific conditions. This amendment supersedes Amendments 1, 4, 11, 12, 13, and 15.
July 28, 1982	Amendment #18 exempts the first 3 million gallons of treated raffinate from the molybdenum requirement if used only on KM owned land.
November 12, 1982	Amendment #19 exempts the treated raffinate storage ponds from the spare ponding requirement. Expires or September 1, 1983.
January 18, 1983	Amendment #20 changes Conditions 3.b. and 6 of Amendment #17.

TABLE 1 - CONTINUED

DATE	DESCRIPTION
April 20, 1983	Amendment #21 changes Condition 15 to terminate benthic organism sampling but to continue sediment samples.
May 18, 1983	Amendment #22 authorizes the injection of 5 million gallons of treated liquid raffinate in the Sequoyah waste disposal well.
September 28, 1983	Amendment #23 exempts the treated raffinate storage ponds from the spare ponding requirement. Expires on September 1, 1984.
December 16, 1983	Amendment #24 changes Item 1 of license No. SUB-1010 to read: Sequoyah Fuels Corporation.
January 24, 1984	Amendment #25 permits storage of raffinate sludge from clarifier in Pond No. 4 and requests a comprehensive plan for waste disposal by January 24, 1985.
February 16, 1984	Amendment #26 changes Conditions 5, 6, and 7 of Amendment #17. Modifies sampling and analytical requirements.
October 1, 1984	Amendment #27 exempts the treated raffinate storage ponds from the spare ponding requirement. Expires on September 1, 1985.
February 5, 1985	Amendment #28 authorizes the construction and use of Pond No. 5 and requires the construction of a spare pond by September 1, 1985.

B. Process Description

The process used by Sequoyah Fuels in the production of UF_6 from uranium ore concentrates is presented in Figure 2 and outlined below:

1. Sampling - Ore concentrates are received in 55-gallon drums which are weighed, sampled by the falling stream method, and redrummed or sent directly to a digester feed bin.

2. Digestion - Ore concentrates are digested with preheated nitric acid in a batch process to form uranyl nitrate.

3. Solvent Extraction - Uranyl nitrate is purified by solvent extraction using tributyl phosphate in n-hexane followed by reextraction to an aqueous solution.

4. Denitration - Purified uranyl nitrate is decomposed at approximately 550° F to produce uranium trioxide.

5. Reduction - Uranium trioxide is pulverized and then reduced to uranium dioxide in two fluid-bed reactors using cracked ammonia.

6. Hydrofluorination - Uranium dioxide is converted to uranium tetrafluoride using anhydrous HF vapor in two stages of stirred fluid bed reactors.

7. Primary Fluorination - Uranium tetrafluoride is converted to uranium hexafluoride by reaction with elemental fluorine. Uranium hexafluoride is condensed in cold traps, then melted and drained into shipping containers.

III. POSSESSION LIMITS

Sequoyah Fuels Corporation has requested the following forms and quantities of source material as limits for the renewal of SUB-1010:

6. Material	7. Form	8. Quantity
Source	Any Form	20 million MTU

IV. FACILITIES

The principal structures at the Sequoyah Facility include the main process and administration building, the solvent extraction facility, and the yellowcake slurry receiving facility. The administration and laboratory area, main process and sampling area, shop and utility area, fluorine generation

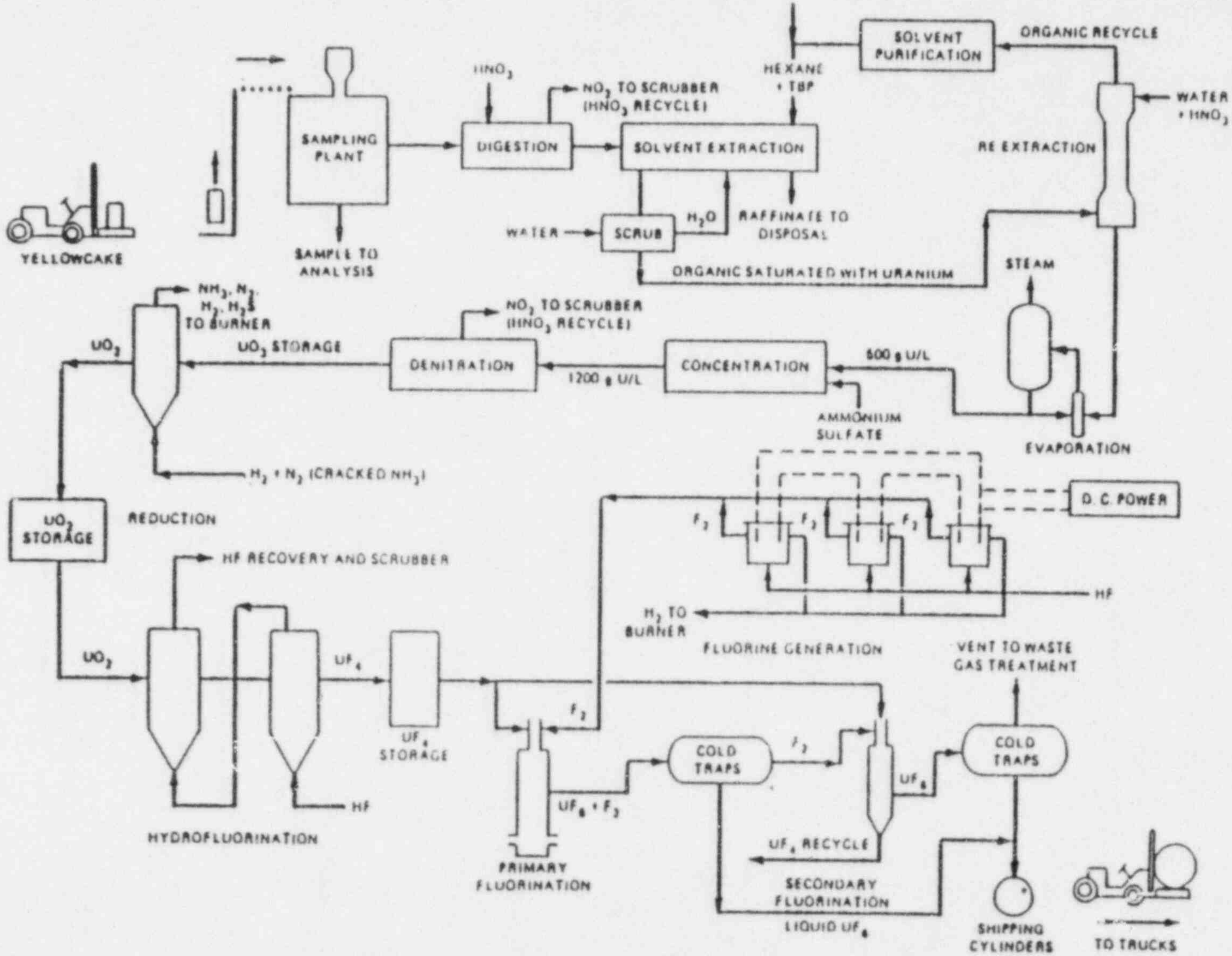

FIGURE 2 - UF_6 CONVERSION FLOW CHART

SEP 20 1985

area, and boiler area are all located in the main process and administration building. Retention ponds for sanitary sewerage, fluoride treatment and clarification, and raffinate storage are located west and south of the plant buildings. The relative locations of these structures are shown in Figure 3.

V. LICENSE APPLICATION

A. Review History

The safety review of the Sequoyah Fuels renewal application included an evaluation of the application transmitted by letter dated September 24, 1982, its revision dated October 17, 1983 (by letter dated November 4, 1983), subsequent page revisions dated May 21, 1984 (by letter dated May 23, 1984), August 13, 1984 (by letter dated August 20, 1984), September 18, 1984 (by letter dated September 24, 1984), and December 6, 1984 (by letter dated December 14, 1984), and the revision of Chapters 1 through 8 dated August 23, 1985.

During the review, a number of site visits were made to the facility by members of the NMSS staff. These included visits by B. Kosla on February 14-18, 1983; B. Kosla and W. T. Crow on November 26-27, 1984; and D. Cool and M. Horn on June 5-6, 1985. The NMSS staff has also met with representatives of Sequoyah Fuels and Kerr-McGee Corporation at the NRC offices in Silver Spring, Maryland.

B. Current Application

The application for renewal is divided into two basic sections, the license conditions section, contained in Chapters 1 - 8, and the demonstration section, Chapters 9 - 17. In the license conditions section, the licensee has committed to minimum requirements for which he will be held accountable. Accordingly, Condition No. 9 incorporates Chapters 1 - 8 as a condition of the license and shall read as follows:

9. Authorized Use: For use in accordance with the statements, representations, and conditions contained in Chapters 1 through 8 of the license renewal application dated August 23, 1985.

The operations described in the application have been and will continue to be conducted at the existing facilities in Gore, Oklahoma. Accordingly, Condition No. 10 incorporates this location as the authorized place of use and shall read as follows.

10. Authorized Place of Use: The licensee's existing facilities at Gore, Oklahoma.

VI. PERFORMANCE HISTORY

A. Regulatory Compliance

The compliance history of Sequoyah Fuels Corporation was reviewed based upon the eight health and safety inspections conducted by

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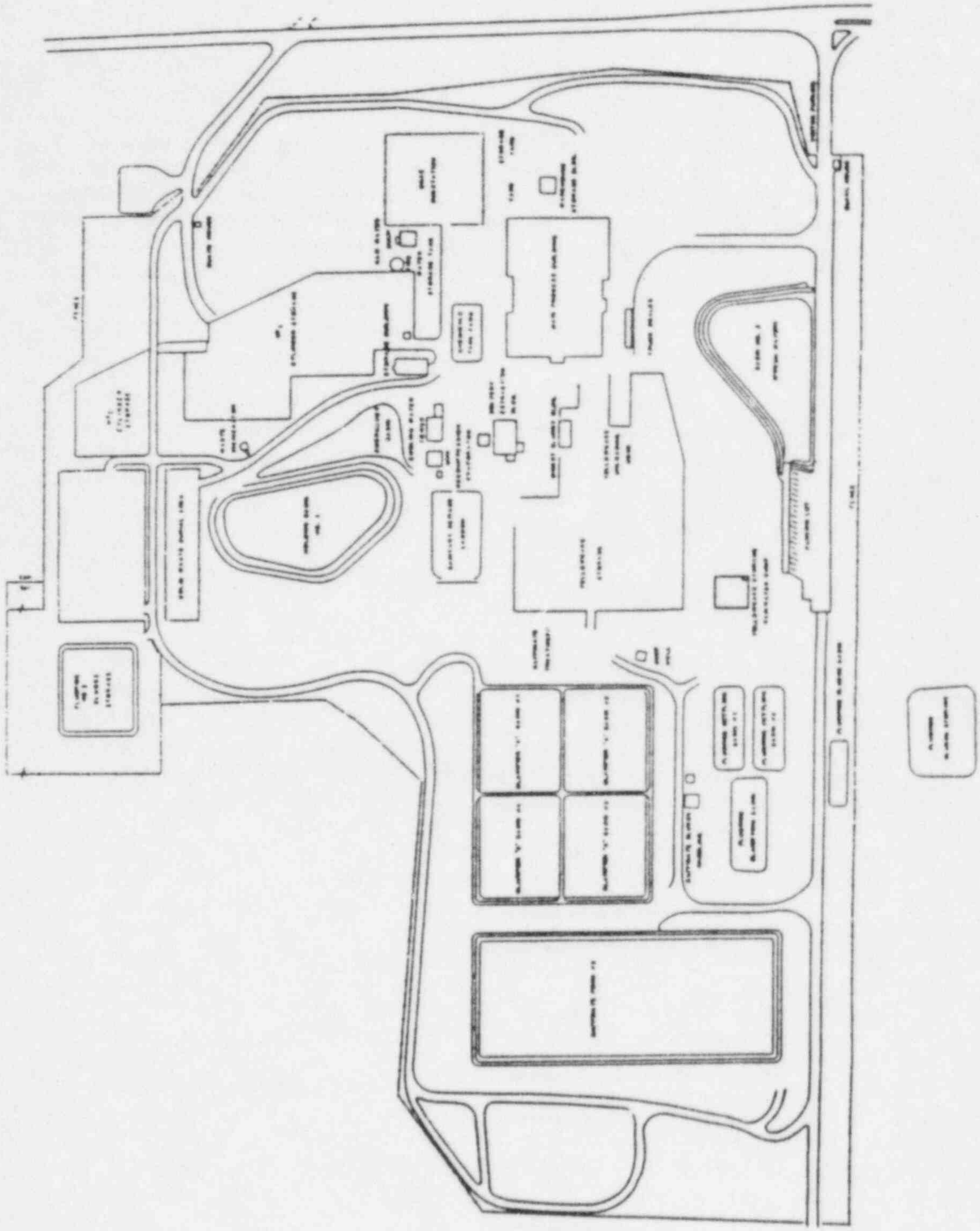
FIGURE 3 - PLOT PLAN OF THE SEQUOYAH FUELS CORPORATION FACILITY



Region IV personnel since October 7, 1977. A summary of the inspection results is given in Table 2.

During the time period since the last renewal, a total of 15 violations or items of noncompliance has been observed. These violations were classified as infractions from 1978 through 1980, and Severity Levels IV, V, or VI from 1981 onward. These are considered to be the least significant types of violations. Several of these have been for repeated problems such as inappropriate use of half-mask respirators for respiratory protection, failure to survey and collect appropriate samples, and failures to properly post and control access to radiation areas. While these items are not severe in terms of their consequences to employee health and safety, the total number of violations is excessive, and the presence of repeated problems indicates a lack of management oversight for operations involving source material.

In response to NRC staff concerns regarding management oversight, Sequoyah Fuels has committed, in Chapter 2.8, to a monthly inspection of all radiation safety-related activities and quarterly audits by the Director, Regulatory Compliance, for compliance with federal and state regulations, NRC license conditions, permits, corporate policies, and facility procedures. The inspections and audits shall be conducted in accordance with preconceived written plans and reports and recommendations made to the Facility Manager. These commitments should improve management oversight and control and thereby reduce the number of radiation safety problems encountered.

B. External Exposures

At Sequoyah Fuels, 96 percent of the employees receive an annual external dose of less than 500 mrem. This level is 10 percent of the occupational exposure limits given in 10 CFR Part 20.

Table 3 presents a summary of exposures for 1979 through 1983. During this time period, the distribution of doses has remained constant without any obvious trend towards increased or decreased levels. A pattern such as this is expected in a facility in which operations and procedures have been improved and there are no major changes in the processes being conducted.

C. Internal Exposures

The primary means for determining compliance with the requirements of 10 CFR Part 20.103 is by measurement of airborne radioactivity. Table 4 gives air sampling averages for various areas within the facility for 1979 through 1983. These data indicate that airborne activity levels have been reduced considerably during the past 5 years.

TABLE 2 - SUMMARY OF LICENSE INSPECTION FINDINGS

Inspection Dates	Summary of Results
August 10-11, 1978	1. Infraction: Respiratory Protective Equipment. a. Incomplete fitting and training. b. Failure to test half-masks for fit. c. Straps over hard hat rather than head. 2. Infraction: Failure to control access to a high radiation area. 3. Infraction: Failure to adopt appropriate procedures. 4. Infraction: License Condition 9. a. Surface contamination in excess of control values. b. Failure to conduct tests of licensing effectiveness. 5. Infraction: Soil samples not collected as specified in Condition 12. 6. Infraction: Failure to collect sediment samples as specified in Condition 15.
December 4-5, 1978	Investigation of release of licensed material to unrestricted areas on December 1, 1978. No items of noncompliance.
May 21-24, 1979	Infraction: Straps for half-mask respirators worn over hard hat rather than head.
July 23-25, 1980	Infraction: Straps of half-mask respirators worn over hard hat rather than head.
February 22-25, 1982	1. Severity Level IV violation: Inadequate surveys for airborne uranium.

TABLE 2 - CONTINUED

Inspection Dates	Summary of Results
	2. Severity Level VI violation: Improper posting of radiation area.
	3. Severity Level V violation: Failure to sample main plant stack.
February 14-18, 1983	1. Severity Level IV violation: Failure to perform surveys.
	2. Severity Level IV violation: Failure to properly sample HF off gas stack.
July 17-19, 1984	No violations of NRC requirements.
March 11-15, 1985	1. Severity Level V violation: Failure to post radiation area.
	2. Severity Level V violation: Failure to decontaminate areas in excess of action levels.

TABLE 3 - PERSONNEL WHOLE BODY EXPOSURE

Annual Dose Ranges (Rem)	Number of Individuals In Each Range				
	1979	1980	1981	1982	1983
Minimal Exposure	8	10	23	18	16
Measureable Exposure 0.10	57	88	89	80	45
.10 to .249	52	35	42	36	51
.250 to .499	33	38	23	24	33
.500 to .749	4	8	4	4	9
.750 to .999	2	1	1	1	4
1.00 to 1.99	0	1	0	0	2
2.00 to 2.99	0	0	0	0	0
3.00 to 3.99	0	0	0	0	0
4.00 to 4.99	0	0	0	0	0
5.00 to 5.99	0	0	0	0	0
6.00 to 6.99	0	0	0	0	0
7.00 to 7.99	0	0	0	0	0
8.00 to 8.99	0	0	0	0	0
9.00 to 9.99	0	0	0	0	0
10.0 to 10.9	0	0	0	0	0
11.0 to 11.9	0	0	0	0	0
12+					

TABLE 4 - AIR SAMPLING AVERAGES BY YEAR BY AREAS (MPC)

Operating Area(s)	Number of Sample Location	1979	1980	1981	1982	1983
Sampling Plant	5	.26	.26	.14	.11	.09
Digestion	4	.18	.28	.23	.20	.13
Denitration	6	.35	.41	.15	.18	.13
Reduction & Hydrofluorination	11	.42	.55	.18	.22	.18
Fluorination	11	.26	.39	.17	.09	.10
Miscellaneous Areas	8	.07	.11	.05	.09	.03

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Sequoyah Fuels utilizes both in vivo and urinalysis bioassay to determine the amount of uranium which may be present in an employee's body. Table 5 presents the average urine uranium data for 1979 through 1983. During this time period, the average urine uranium values have decreased in keeping with airborne radioactivity levels.

In vivo bioassay, consisting of annual or biannual lung counting, is performed to determine if an insoluble uranium burden has been accumulated by an employee. Lung count data indicates that insoluble uranium in the lung is generally below detection levels.

D. Conclusions

Based upon the data presented in the preceding sections, the staff finds that Sequoyah Fuels Corporation has operated within the basic health and safety principles and in accordance with the ALARA philosophy. Although compliance with regulations and license conditions has been marginal, an improved management oversight of the facility should provide a continued appropriate level of radiation protection and compliance.

VII. ORGANIZATION AND ADMINISTRATION

A. Organization

Sequoyah Fuels Corporation is a wholly-owned subsidiary of Kerr-McGee Corporation. The Kerr-McGee Corporation (KM) is an integrated natural resource company whose divisions and subsidiaries include interests in oil and gas, contract drilling, uranium and nuclear fuels, plant foods, minerals, and preserved wood products. An organizational chart for Sequoyah Fuels Corporation is shown in Figure 4.

1. Supervision and Responsibility

The Vice President is responsible for all nuclear manufacturing activities and for the selection of personnel for all safety-related staff positions and safety review committee memberships. The Facility Manager reports to the Vice President of Sequoyah Fuels and is responsible for safe and efficient operation of the facility and for control of all material at the site. Operations conducted under the direction of the Facility Manager are administered through seven departments: (1) Health Physics and Industrial Safety, (2) Production, (3) Maintenance and Construction, (4) Conversion Engineering, (5) Industrial Relations, (6) Administration and Accountability, and (7) Laboratory.

The Manager of Health Physics and Industrial Safety is the facility Radiation Safety Officer (RSO) and is responsible for the conduct of the health physics and industrial safety program. The Conversion Engineering Manager provides and supervises engineering services

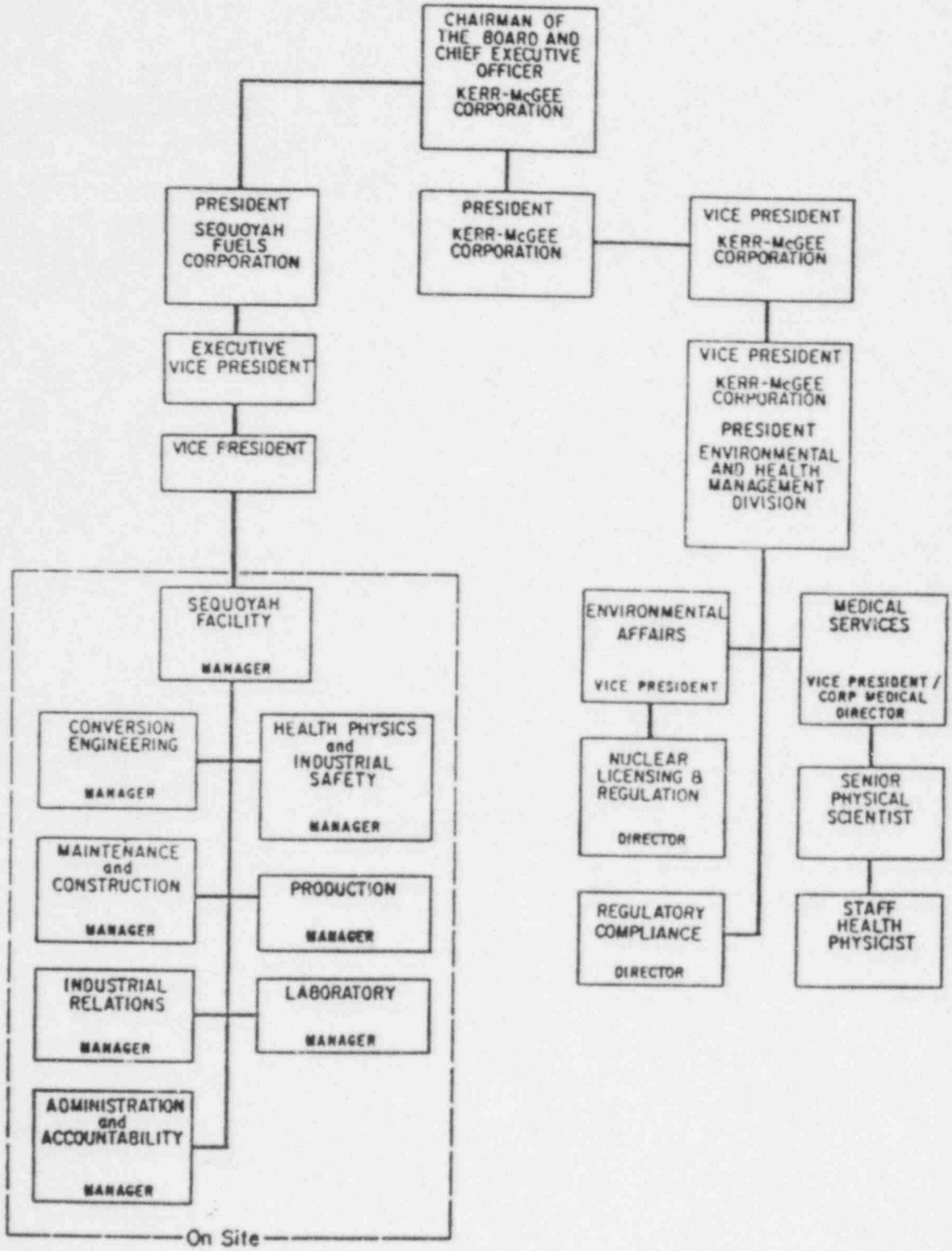
TABLE 5 - AVERAGED URINE SAMPLING DATA* FOR ALL PERSONNEL

	1979 μgm/ℓ**			1980 μgm/ℓ**			1981 μgm/ℓ**			1982 μgm/ℓ**			1983 μgm/ℓ**		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Sampling Plant Operators	26	12	19	26	5	15	12	6	9	11	4	7	14	5	8
Production Personnel	45	7	18	54	4	14	27	4	9	22	3	7	58	3	8
Maintenance Personnel	58	9	22	43	5	15	51	2	10	16	3	7	16	4	7
All Others	54	7	17	23	4	9	12	2	2	9	3	4	9	4	5
Background			6			6			6			6			6

*Does not include special samples obtained because of unusual occurrences.

**Concentration determined by fluorimetric method (uranium).

FIGURE 4 - ORGANIZATIONAL CHART



for process design modifications, process evaluations, and the monitoring of operational conditions. The Manager of Production is responsible for all operational activities.

The Director, Nuclear Licensing and Regulation, Kerr-McGee Corporation, is responsible for federal and state licenses and permits, liaison with the regulating agencies, and for coordinating with the Facility Manager in matters of licensing requirements. The Staff Health Physicist, Environment and Health Management Division, is responsible for detailed standards for the prevention, control, and monitoring of radiation exposure and for auditing health physics operations.

2. Minimum Qualifications

The safety-related positions shown in Figure 4 are filled by individuals who meet stated minimum qualifications of academic training and experience as follows:

The Facility Manager shall have at least 5 years' experience in management of manufacturing facilities with at least 3 years management experience in nuclear manufacturing facilities. He shall hold a bachelors degree in science or engineering and have demonstrated the proficiency to manage significant portions of required management activities.

The Manager, Health Physics and Industrial Safety, shall hold a degree in science or engineering and have at least 2 years' experience in radiation monitoring and personnel exposure or shall have a high school diploma and at least 10 years' experience in radiation monitoring and personnel exposure evaluation. He shall have demonstrated a proficiency to: (1) conduct specified radiation safety programs, (2) recognize potential radiation safety problem areas in the operations, and (3) advise operation supervision on radiation protection matters. He must also be capable of directing the surveillance activities of health physics technicians.

The Manager of Conversion Engineering shall hold a degree in science or engineering or equivalent, with broad experience in chemical processing, uranium processing, and chemical materials handling.

The Manager of Production shall hold a bachelors degree in science or engineering with 5 years' experience in a supervisor position. He shall have demonstrated a proficiency to manage the operations of the Sequoyah Facility and to identify process changes which require health physics analysis.

The Area Supervisor shall have broad supervisory industrial chemical processing experience or a degree in science or engineering with a general background in the production and handling of uranium materials.

The Shift Supervisors shall have a bachelor degree with 2 years' experience in working with radioactive materials or a high school diploma with 5 years' experience in chemical plant processing. The Shift Supervisors shall be thoroughly familiar with the uranium production activities and have thorough knowledge of the approved operating procedures.

The Director, Nuclear Licensing and Regulation (Environment and Health Management Division of Kerr-McGee Corporation), shall hold an advanced degree in engineering or science or its equivalent, with at least 8 years in technical management, 5 of which involve nuclear activities.

The Staff Health Physicist (Environmental and Health Management Division of Kerr-McGee Corporation), shall be professionally qualified with a bachelors degree in science or engineering and shall have had 5 years' experience in assignments involving radiation protection. He shall be capable of providing authoritative advice and counsel in matters of health physics, industrial hygiene, and industrial safety.

B. Administrative Practices

1. ALARA

The Sequoyah Fuels commitment to conduct operations in accordance with the ALARA principle is demonstrated through administrative practices and the history of operations at the facility. Improvements through both engineering and administrative actions have resulted in a decrease in high airborne radioactivity levels and a significant decrease (from 552 to 153) in the number of persons requiring special urine sampling as a result of an incident.

An ALARA Committee is established, as described in Chapter 3.1.2 of the licensee's application, to evaluate trends and analyses supplied by the Corporate Staff Health Physicist. The ALARA Committee also reviews exposure and effluent release data to determine if there are any upward trends, if exposures and releases might be lowered, and if equipment for effluent control is operating properly. The ALARA Committee meets on an annual basis and documents its meetings.

Membership of the ALARA Committee consists of individuals from both Sequoyah Fuels Corporation and Kerr-McGee Corporation. The membership includes the Corporate Medical Director, Director of Licensing and Regulation, Staff Health Physicist, Vice President of Sequoyah Fuels, Facility Manager, Radiation Safety Officer, and managers of the Production, Maintenance and Engineering Departments.

2. Procedures

As specified in Chapter 2.7 of the license renewal application, written operating procedures shall be established, maintained, and adhered to for all operations involving source material. As specified by the license renewal application, the phrase "adhered to" implies that all operations shall be conducted in accordance with the approved written operating procedures. These procedures shall be reviewed and revised as necessary on an annual basis and whenever necessary to reflect changes in the facility.

Procedures are based upon the Health and Safety standards established and published by the Kerr-McGee Corporation Environment and Health Management Division. These standards are prepared under the direction of the Staff Health Physicist, are reviewed for license compliance and operability by Nuclear Licensing and Regulation and the Facility Manager respectively, and approved by the Vice President, Sequoyah Fuels Corporation.

Operating procedures, prepared by production personnel, are reviewed by the Production Manager who is responsible for formulating, developing, and maintaining detailed operating procedures. These are reviewed by the RSO and are approved by the Facility Manager.

Radiation safety procedures are contained in the facility manual which uses the corporate manual as a guide. The facility manual is prepared by the RSO, concurred in by the Production Manager, and is approved by the Facility Manager.

3. Radiation Work Permits

Unplanned or nonroutine work is controlled by a radiation work permit system termed the Hazardous Work Permit (HWP). An HWP is an authorization to perform specific tasks which have the potential for increasing the risk of personal exposure to radiation or radioactive materials. HWP's shall be issued for all operations associated with licensed material which are not covered by established procedures as specified in Chapter 3.1.1 of the license renewal application.

The development and approval of HWP's are initiated by the work area supervisor and reviewed by the RSO or Health Physics Technician. Persons working under an HWP are informed of the hazards and precautions and a copy of the permit posted at the boundary of the work site. HWP's are terminated and reissued if the task or conditions change.

4. Records

As specified in Chapter 2.10 of the license renewal application, all plant and personnel health physics data and reports shall be recorded and filed. The records of surveys and personnel exposure are retained in accordance with NRC regulations.

C. Inspections and Audits

Monthly inspections of radiation safety activities at the facility are conducted by the RSO in accordance with a written plan. A report summarizing the results is submitted to the Facility Manager.

Audits to evaluate and verify compliance with applicable federal and state regulations, NRC license conditions, permits, corporate policies, and facility procedures are conducted on a quarterly basis by the Director, Regulatory Compliance in accordance with a preconceived written plan. A formal report of findings, observations, and recommendations is prepared and submitted to the Director by Compliance Specialists who actually perform the audit. After review, the report is forwarded to the Facility Manager. This report also serves as an information base for the ALARA Committee.

D. Personnel Training

Radiation safety training is given to all personnel, including contract personnel, prior to working with source material. The training consists of both classroom and in-plant instruction in the areas of radiation safety, plant operations, equipment operations, and emergency procedures. A minimum of 6 hours of formal lecture and demonstrations related to health and safety is provided by health and safety personnel. An orientation checklist is maintained to assure attendance participation and coverage of the subject material.

Retraining is conducted by line supervision or health physics personnel at monthly safety meetings for continual employee awareness of safety.

E. Product Cylinder Handling

A large number of accident scenerios have been examined as part of the safety and environmental reviews. The staff has identified the rupture of a hot cylinder containing liquid UF_6, resulting in the release of UF_6 to the main processing building and the environment, as the most likely scenerio having potentially severe consequences for health, safety, and the environment.

Cylinders containing liquid UF_6 are moved and handled using a large forklift vehicle and an air driven weighing scale dolly. Hot cylinders are moved by forklift from the steam chests to the scales and from the scales to the storage area where cylinders are allowed to cool. The movement of cylinders involves both outdoor and indoor areas. In general, cylinders are lifted only a short distance above the ground while being moved. Under these conditions, cylinders could be ruptured in a number of different ways including dropping and puncturing.

The consequences of a cylinder rupture resulting in the release of UF_6 include inhalation of highly soluble uranium (UF_6 and UO_2F_2) and HF, acid burns from HF in the air, and contamination of facilities and offsite areas. To allow for a detailed staff review of cylinder handling procedures and the plans for mitigating measures in the event of a release, the staff recommends that the following condition be incorporated in the renewed license:

11. Within 6 months of the issuance of this license, the licensee shall prepare and submit to the Uranium Fuel Licensing Branch the following reports. These reports shall contain sufficient detail and analysis to allow an independent review and shall contain licensee commitments for the actions described.

    a. A report detailing handling procedures for product cylinders containing liquid UF_6. The report shall include a detailed analysis of each step in the handling of hot cylinders and identify the possible scenerios which could result in cylinder rupture. The report shall also provide an assessment of the modifications and actions which could be taken to reduce the potential for a UF_6 release and justify the procedures being used.

    b. A report detailing measures and actions to mitigate the effects of a UF_6 release. The report shall deal with the potential release of material within the facility and outside of the facility.

F. Conclusions

Sequoyah Fuels Corporation and its parent company, Kerr-McGee Corporation, have established as part of the license renewal application an organizational and administrative system for the safe operation of the Sequoyah Facility. Positions of importance have been filled with personnel which meet the minimum qualifications for their level of responsibility. Operations are conducted in accordance with approved written procedures or are subject to a radiation work permit system such that all activities at the facility have been evaluated for radiation safety and appropriate precautions established. Employees are provided with training prior to working with radioactive materials and are provided with refresher instruction as part of an ongoing safety program. The staff finds that the licensee's organizational and administrative commitments are sufficient to operate the facility and protect the health and safety of employees.

VIII RADIATION PROTECTION

A. External Exposure Control

External exposure levels due to work with uncontained uranium are generally not significant due to the low specific activity of the source material. Personnel working with source material are provided with film badges which are exchanged and evaluated on a monthly basis. In addition, random field measurements of exposure rates are made by the RSO using a calibrated ionization chamber.

B. Internal Exposure Control

1. Ventilation

Areas which are used to process source materials are provided with ventilation measures in the form of building ventilation and containment systems. Building ventilation is provided with a minimum of 10 air changes per hour in the processing area, 31 air changes per hour in the fluorine cell, and 12 air changes per hour in the solvent extraction building. Air in the process building is exhausted through 11 3000 cfm powered vents and 11 powered roof hatch exhausts with a rated capacity of 563,000 cfm. The ventilation airflow is from areas of lesser potential for contamination to areas of greater potential.

Containment systems, such as equipment enclosures, tank covers, and powder bins, are designed to operate under negative pressure with respect to the room to prevent the release of radioactive materials. Additional controls, such as shrouds and hoods, are provided to remove dust from potential leakage points. A minimum face velocity of 100 LFM is maintained at the entrance for all hoods and exhausted enclosures. Surveys are conducted monthly to assure that this condition is met.

2. Air Sampling

Airborne radioactivity levels are measured by 45 general air samplers located throughout the processing area. Samplers are located approximately 5 to 6 feet above floor level and are sampled at a flow rate of at least 1 cfm. Flow rates are checked on a weekly basis. Sample filters are collected from the sampling heads once each work shift or more often in the event of a known or suspected leakage. The representativeness of fixed air samplers is evaluated at least once per year or whenever a major operational change is made.

Air sampling results greater than the facility action level of 0.5 MPC for general breathing air, when averaged over an 8 hour work shift, require investigation and correction of the cause. A facility action level of 3 MPC is established for abnormal airborne incidents. When corrective action cannot be taken immediately and airborne concentrations exceed 1 MPC, respirators are used until the corrective action is taken.

3. Bioassay

The bioassay program consists of urinary uranium analysis to determine exposures to soluble uranium compounds and in vivo whole body counting to determine lung deposition of insoluble compounds. The program meets the requirements of Regulatory Guides 8.9 and 8.11.

Urinary bioassay samples are routinely collected twice monthly. Special diagnostic samples are collected following a known significant exposure. Samples for non-transportable uranium compounds require the collection of 24-hour samples while transportable (especially UF_6 and UO_2F_2) require collection of single samples during the 24-hour period. An action level of 20 µg/l requires a second sample and if confirmed, the employee is placed on work restrictions until the concentration drops below 20 µg/l. Concentrations greater than 100 µg/l require immediate work restriction.

In vivo lung counting to detect internal deposition of insoluble (non-transportable) uranium is performed annually for employees whose routine urinalysis is consistently above 20 µg/l, is exposed to known insoluble uranium, or whose previous lung counts show a significant fraction of the uranium body burden. All other employees are counted once every 2 years.

4. Respiratory Protection

The respiratory protection program used at the facility shall be in accordance with Regulatory Guide 8.15. Respirators are used in locations where airborne concentrations have the potential to exceed 1 MPC and as required by hazardous work permits.

Before working in the controlled area, each employee is fitted with each type of respirator (half-mask, full face, supplied air) and checked for respirator seal by using a smoke tube and polydisperse DOP aerosol test system. The protection factors assigned are in accordance with 10 CFR Part 20, Appendix A. Appropriate records are kept of the respirator seal tests.

C. Contamination Control

1. Access Control

Access to the plant operating area is restricted by a 6-foot security fence fitted with intrusion detectors and monitored by a closed-circut television system. A guard station is provided at the facility entrance. Employees and visitors must pass the guard station before gaining access to the restricted area.

All persons entering and exiting the controlled area must pass through a change room. Employees entering the controlled area are required to wear coveralls, process area safety shoes, hard hats and safety glasses. Upon exiting the controlled area, washing and/or monitoring is required to determine if contamination is present on skin or personal clothing. Specific approval of the RSO is required for exiting with contamination in excess of detection levels on the skin or 100 dpm/100 cm^2 on clothing.

All entrances to the controlled areas are conspicuously posted in accordance with 10 CFR Part 20.203(e)(2).

2. Surface Contamination Control

Surface contamination monitoring and control are performed in accordance with the guidelines given in Regulatory Guide 8.30. Visual inspections for surface contamination are performed on each shift and any observed contamination removed promptly. Surface contamination surveys are conducted on a weekly basis, and any areas which exceed the guidelines given in Chapter 3.2.4.7 of the license renewal application are cleaned within 72 hours of notification of the survey results. The action levels for smearable contamination are 2,000 dpm/100 cm^2 for uranium processing areas, 1,000 dpm/100 cm^2 for shops and storage areas, and 500 dpm/100 cm^2 for uncontrolled areas.

3. Personnel Protective Equipment

Personnel engaged in operations where possible contamination may be encountered are provided with coveralls, work shoes, hard hats, and safety glasses. When required through evaluations for Hazardous Work Permits, additional personal protection such as respirators, acid suits, shoe covers, hoods, and face shields may be used.

D. Conclusions

The staff finds that the radiation protection program established by Sequoyah Fuels Corporation is in keeping with standard health physics practice, meets the requirements of the applicable NRC Regulatory Guides, and is sufficient to protect and monitor employees.

IX. ENVIRONMENTAL PROTECTION

The staff has evaluated the environmental impacts of the continued operation of the Sequoyah Facility in the Environmental Assessment (NUREG-1157) dated August 1985. As a result of this Environmental Assessment, a Finding of No Significant Impact was prepared and published in the *Federal Register*.

The Environmental Assessment contains a number of staff recommendations for conditions to ensure that operations continue to comply with the applicable state and federal standards. The staff recommendations may be implemented in the licensing process in several different ways including incorporation of the recommendations by the licensee into the license renewal application and by conditions written by the NRC staff at the time the license renewal is issued. Both of these options have been used to incorporate the staff recommendations into the license renewal. The following is a summary of the staff recommendations and the method of incorporation into the license:

1. The licensee shall sample the main stack continuously and analyze for gross alpha on a daily or weekly basis.

   This condition has been incorporated by the licensee in Chapters 3.2.2 and 5.1.2 of the revised application dated August 23, 1985. The commitment made by the licensee was for the main stack to be sampled continuously and analyzed for gross alpha activity on a daily basis.

2. The average uranium concentration in the raffinate used in the fertilizer program shall not exceed 0.1 mg/l.

   This condition has been incorporated by the licensee in Chapter 1.8 of the revised application dated August 23, 1985. The commitment made by the licensee is worded identically to the staff recommendation as it appeared in the Environmental Assessment.

3. Within 3 months of the renewal of this license, the licensee shall reevaluate the existing groundwater conditions in the area of the treated raffinate storage ponds and prepare and submit for NRC review a report which describes these conditions and either justifies the current monitoring program or proposes a new program for groundwater monitoring.

   The staff recommends that this condition be incorporated as Condition 12 of the renewed license.

4. Within 3 months of the renewal of this license, the licensee shall submit to NRC for review and approval a supplemental vegetation monitoring program to provide additional information for the radiological assessment on the ingestion pathway. The vegetation monitoring program shall include the sampling of food crops in the general area. The vegetation samples collected shall be analyzed for uranium, Ra-226, and Th-230. The licensee shall be able to use these data to assess the radiological impact to any member of the general public exposed from the ingestion pathway. A report of the findings shall be submitted to NRC for review. The program shall be initiated on the next growing season upon approval by NRC.

The licensee shall report the concentrations of radionuclides in vegetation on a dry basis and supply the percent moisture.

The staff recommends that the first part of this condition be incorporated as Condition 13 of the renewed license.

The second part of this condition has been incorporated by the licensee in Chapter 1.8 of the revised application dated August 23, 1985. The commitment made by the licensee was identical to the condition recommended by the staff.

5. The licensee shall investigate and verify that the elevated uranium and nitrate concentrations found in Well FTP-2A are not the results of the liquid seepage from Ponds 3 or 4. A report of the investigation shall be submitted to NRC within 6 months from the date of renewal of the license.

   The staff recommends that this condition be incorporated as Condition 14 of the renewed license.

6. The licensee shall propose an appropriate surface water monitoring program to determine the total quantity of uranium discharged to the environs from the runoff drainage ditches which are not included in the NPDES permit. The proposed program shall be submitted to NRC for review and approval within 3 months from the date of renewal of the license.

   The licensee shall investigate the cause of some of the elevated uranium concentrations in the above runoffs. Within 3 months from the date of renewal of the license, a report of the investigation shall be submitted to NRC. The report shall describe what mitigating measures, if any, were taken to eliminate the source(s).

   The staff recommends that these conditions be incorporated as Conditions 15 and 16 of the renewed license.

7. The licensee shall conduct a comprehensive soil/sediment radiological survey to determine the extent of uranium accumulation along the length of the effluent stream (001), at the confluence, upstream and downstream of the Illinois River, and along the intermittent runoff areas identified above (Number 6). The results of this survey and any recommendations for mitigation shall be reported to NRC within 12 months from the date of the renewal of the license.

   The staff recommends that this condition be incorporated as Condition 17 of the renewed license.

8. The licensee shall follow the quality assurance program as specified in NRC's Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Program (Normal Operation)-Effluent Streams and Environment."

This condition has been incorporated by the licensee in Chapter 5.2 of the revised application dated August 23, 1985. The commitment made by the licensee was for compliance with the quality assurance procedures outlined in Regulatory Guide 4.14, "Measuring, Evaluating, and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Uranium Mills," and those sections of Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," which apply to a uranium conversion facility.

9. If the radioactivity in plant gaseous effluents exceeds 30,000 μCi per calendar quarter, the licensee shall, within 30 days, prepare and submit to the Commission a report which identifies the cause for exceeding the limit and the corrective actions to be taken by the licensee to reduce release rates. If the parameters important to a dose assessment change, a report shall be submitted within 30 days which describes the changes in parameters and includes an estimate of the resultant change in dose commitment.

   The licensee had previously incorporated a majority of this condition in Chapter 5.1 of the license renewal application. The licensee has incorporated the remaining provisions of this condition as part of Chapter 5.1 of the revised application dated August 23, 1985.

10. The licensee shall conduct a dose assessment on a quarterly basis using site-specific information and methodology in Appendix A of the Environmental Assessment. If the quarterly dose commitment to a maximally-exposed individual in the general public exceeds 6.25 mrem for any organs, a report shall be submitted to the Commission within 30 days of the determination of the quarterly dose. In the event that the calculated dose to any member of the public in any consecutive 12-month period is about to exceed the limits specified in 40 CFR 190.10, the licensee shall take immediate steps to reduce emissions so as to comply with 40 CFR 190.10. As provided in 40 CFR 190.11, the licensee may petition the Nuclear Regulatory Commission for a variance from the requirements of 40 CFR 190.10. If a petition for a variance is anticipated, the licensee shall submit the request at least 90 days prior to exceeding the limits specified in 40 CFR 190.10.

    This condition has been incorporated by the licensee in Chapter 5.1 of the revised application dated August 23, 1985.

11. Within 3 months of the renewal of this license, the licensee shall submit to NRC for review and approval an improved system for the transference of liquid waste from the plant to be discharged to the Illinois River.

    By letter dated August 9, 1985, the licensee submitted for NRC review and approval the above plan. Thus, there is no need for this condition to be incorporated into the revised license.

The NRC staff, in Chapter 4 of the Environmental Assessment, noted that because raffinate leakage had caused contamination of the soil and groundwater beneath and near Pond 2, Sequoyah Fuels was required to decommission Pond 2 and remove all sludges to a plastic-lined pond for temporary storage. This requirement was applied to the licensee as part of License Amendment 28.

The licensee has complied with this condition through the construction of Pond No. 6 and the initiation of sludge removal from Pond No. 2. Upon completion of the sludge removal, the licensee will decommission Pond No. 2. At the present time, the licensee has not provided for NRC staff review the plan for decommissioning the pond or the criteria which will be used in the decommissioning. The staff therefore recommends the following condition be added to the license:

18. The licensee shall submit for NRC review and approval the plan and criteria for decommissioning Pond No. 2 upon the completion of sludge removal from Pond No. 2.

Another recommendation made by the staff in the Environmental Assessment which was not reflected as a specific condition, was that the licensee set an action level on every sampling media. If an action level is exceeded, Sequoyah Fuels shall conduct an investigation and, if necessary, take mitigating measures. This action level and commitments for action when the level is exceeded are contained in Chapter 5.2 of the revised application dated August 23, 1985.

As part of License Amendment No. 28, the licensee was required to construct by September 1, 1985, a spare pond having capacity equal to or greater than Pond No. 5. Sequoyah Fuels has attained compliance with this condition through the construction of Pond No. 6. However, the staff believes that Sequoyah Fuels should maintain spare pond capacity at all times. Thus, the staff recommends the following condition be added to the license to ensure the licensee will always have a spare pond capability:

19. The licensee shall maintain a spare pond having capacity equal to or greater than Pond No. 5, unless the licensee's deep well injection plan has been approved.

X. FIRE SAFETY

The Sequoyah Fuels Corporation facilities have been constructed in accordance with National Fire Protection Association Codes and have been approved by the Factory Insurance Association. Noncombustible construction is utilized throughout the facility.

Fire protection for the solvent extraction building is provided by a foam deluge system which is capable of providing a foam-water mixture for approximately 8 minutes. A backup foam tank capable of producing an additional 8 minutes of deluge is also provided. Fire protection in the Main

Process Building is provided by 43 wall mounted extinguishers and sprinklers over electrical cable trays in congested areas. Surrounding the building is a 10-inch diameter fire water main with 6-inch laterals serving nine hydrant stations. The fire water system will supply 1,000 gpm at 100 psig to any hydrant. A minimum of 150,000 gallons of water are reserved for fire protection purposes in a water storage tank.

XI. DECOMMISSIONING PLAN

Chapter 7 of the license renewal application contains the decommissioning plan for the Sequoyah Fuels Corporation facility. This plan is similar to the plan approved by the NRC and incorporated as Condition No. 3 of the present license. Differences in the two plans relate mainly to the amount of descriptive material provided to support the plan assumptions.

Decommissioning of the facility has been assumed possible without the complete removal of all buildings. Certain floor areas and much of the equipment is assumed to be removed. The plan also assumes the fluoride and raffinate sludges have been processed and disposed of prior to the decommissioning action. Ponds and lagoons are assumed to be drained and the liners buried. According to 10 CFR Part 20, application may be made to the Commission for burial of radioactive material. Burial of material without the approval of the NRC is not allowed. The licensee has indicated that burial of materials shall not be made without the prior approval of the NRC.

Financial assurance of the performance by Sequoyah Fuels Corporation of its obligation to provide funds for decommissioning was provided by a letter to Mr. J. B. Martin from Mr. F. A. McPherson, President of Kerr-McGee Corporation, dated October 26, 1978. This letter is referenced in Chapter 7.5 of the license renewal application and will therefore become part of the renewed license.

The decommissioning plan provides an adequate description of the steps which will be necessary at the end of plant life to decommission the facility. However, the plan fails to make an explicit commitment on the part of Sequoyah Fuels Corporation to decontaminate and decommission the facility for unrestricted use. The staff therefore recommends the following condition be incorporated into the license:

20. At the end of plant life, the licensee shall decontaminate and decommission the facility so that it can be released for unrestricted use.

The decommissioning plan assumes, for the purpose of estimating costs and the efforts required at the time of decommissioning, that the processing of liquid and sludge waste materials is completed. The costs of processing of liquid and sludge materials is assumed to be part of the operating costs of the facility.

By letter dated May 24, 1985, Sequoyah Fuels submitted for NRC consideration a comprehensive solid waste disposal and storage plan in response to Condition 2 of License Amendment No. 25. This plan provides that raffinate sludge will be stored indefinitely onsite, consistent with the NRC Branch Technical Position "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations." While storage onsite may be acceptable as a temporary position, it does not provide a solution for the ultimate problem of disposal of these raffinate sludge materials. The staff therefore recommends that the following condition be added to the license to ensure that the licensee has, as part of the decommissioning plans and commitments, an acceptable plan for the ultimate disposal of these waste materials and has committed the financial resources to carry out the disposal plan.

21. The licensee shall, by October 1, 1986, prepare and submit changes to the decommissioning plan which provide for the permanent disposal of all solid wastes generated by the facility. The plan shall include an estimate of the costs involved in disposing of these wastes and the financial arrangements that have been or will be made to assure that adequate funds will be available to cover these costs at the time of disposal.

XII. RADIOLOGICAL CONTINGENCY PLAN

Sequoyah Fuels Corporation submitted a Radiological Contingency Plan for the facility on March 11, 1982, which was incorporated into the license as Condition No. 14. Chapter 8 of the license renewal application refers to this plan and provides a brief description of the actions which might be taken to mitigate the effects of an accident. The staff finds that the Radiological Contingency Plan dated March 11, 1982, remains appropriate for the facility and therefore recommends the following condition be added to the license to specifically incorporate this plan as a condition of the renewed license:

22. The licensee shall implement, maintain, and execute the response measures of his Radiological Contingency Plan submitted to the Commission on March 11, 1982. The licensee shall also maintain implementing procedures for his Radiological Contingency Plan as necessary to implement the Plan. The licensee shall make no change in his Radiological Contingency Plan that would decrease the response effectiveness of the Plan without prior Commission approval as evidenced by a license amendment. The licensee may make changes to his Radiological Contingency Plan without prior Commission approval if the changes do not decrease the response effectiveness of the Plan. The licensee shall maintain records of changes that are made to the Plan without prior approval for a period of 2 years from the date of the change and shall furnish the Chief, Uranium Fuel Licensing Branch, Division of Fuel Cycle and Material Safety, NMSS, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555, and the appropriate NRC Regional Office specified in Appendix D of 10 CFR Part 20, a report containing a description of each change within 6 months after the change is made.

By letter dated August 24, 1984, Sequoyah Fuels Corporation submitted copies of changes made in the Radiological Contingency Plan which do not decrease the response effectiveness of the Plan. Staff review of these changes indicates that the majority of these are the result of the change in corporate name from Kerr-McGee to Sequoyah Fuels Corporation. Other changes were made to update calling lists and personnel to be notified. The staff finds that these changes are appropriate to maintain an updated Radiological Contingency Plan.

XIII CONCLUSIONS AND RECOMMENDATIONS

Upon completion of the safety review of the licensee's application and compliance history, the staff has concluded that the activities authorized by the issuance of the renewed license to Sequoyah Fuels Corporation, subject to the additional conditions developed by the Uranium Fuel Licensing Branch staff, will not constitute an undue risk to the health and safety of the public. Further, the staff has determined that the application fulfills the requirements of 10 CFR Part 40.32.

The staff has discussed the renewal and proposed license conditions with Mr. Robert J. Everett, Section Chief, Nuclear Material Safety Safeguards, NRC Region IV. He feels the license, as written, addresses all of Region IV's concerns from an inspection and enforcement perspective and has no objection to the issuance of the renewal.

Pursuant to the provisions of 10 CFR Part 40, the staff therefore recommends that the Sequoyah Fuels Corporation license be renewed for a 5-year term, expiring September 30, 1990, subject to the following conditions:

6. Material	7. Form	8. Quantity
Source	Any Form	20 million MTU

9. Authorized Use: For use in accordance with the statements, representations, and conditions contained in Chapters 1 through 8 of the license renewal application dated August 23, 1985.

10. Authorized Place of Use: The licensee's existing facilities at Gore, Oklahoma.

11. Within 6 months of the issuance of this license, the licensee shall prepare and submit to the Uranium Fuel Licensing Branch the following reports. These reports shall contain sufficient detail and analysis to allow an independent review and shall contain licensee commitments for the actions described.

    a. A report detailing handling procedures for product cylinders containing liquid UF_6. The report shall include a detailed analysis of each step in the handling of hot cylinders and identify the possible scenerios which could result in cylinder rupture. The report shall also provide an assessment of the modifications and actions which could be taken to reduce the potential for a UF_6 release and justify the procedures being used.

b. A report detailing measures and actions to mitigate the effects of a UF_6 release. The report shall deal with the potential release of material within the facility and outside of the facility.

12. Within 3 months of the renewal of this license, the licensee shall reevaluate the existing groundwater conditions in the area of the treated raffinate storage ponds and prepare and submit for NRC review a report which describes these conditions and either justifies the current monitoring program or proposes a new program for groundwater monitoring.

13. Within 3 months of the renewal of this license, the licensee shall submit to NRC for review and approval a supplemental vegetation monitoring program to provide additional information for the radiological assessment on the ingestion pathway. The vegetation monitoring program shall include the sampling of food crops in the general area. The vegetation samples collected shall be analyzed for uranium, Ra-226, and Th-230. The licensee shall be able to use these data to assess the radiological impact to any member of the general public exposed from the ingestion pathway. A report of the findings shall be submitted to NRC for review. The program shall be initiated on the next growing season upon approval by NRC.

14. The licensee shall investigate and verify that the elevated uranium and nitrate concentrations found in Well FTP-2A are not the results of the liquid seepage from Ponds 3 or 4. A report of the investigation shall be submitted to NRC within 6 months from the date of renewal of the license.

15. The licensee shall propose an appropriate surface water monitoring program to determine the total quantity of uranium discharged to the environs from the runoff drainage ditches which are not included in the NPDES permit. The proposed program shall be submitted to NRC for review and approval within 3 months from the date of renewal of the license.

16. The licensee shall investigate the cause of some of the elevated uranium concentrations in the runoffs identified in Condition 15. Within 3 months from the date of renewal of the license, a report of the investigation shall be submitted to NRC. The report shall describe what mitigating measures, if any, were taken to eliminate the source(s).

17. The licensee shall conduct a comprehensive soil/sediment radiological survey to determine the extent of uranium accumulation along the length of the effluent stream (001), at the confluence, upstream and downstream of the Illinois River, and along the intermittent runoff areas identified in Condition 15. The results of this survey and any recommendations for mitigation shall be reported to NRC within 12 months from the date of the renewal of the license.

18. The licensee shall submit for NRC review and approval the plan and criteria for decommissioning Pond No. 2 upon the completion of sludge removal from Pond No. 2.

19. The licensee shall maintain a spare pond having capacity equal to or greater than Pond No. 5, unless the licensee's deep well injection plan has been approved.

20. At the end of plant life, the licensee shall decontaminate and decommission the facility so that it can be released for unrestricted use.

21. The licensee shall, by October 1, 1986, prepare and submit changes to the decommissioning plan which provide for the permanent disposal of all solid wastes generated by the facility. The plan shall include an estimate of the costs involved in disposing of these wastes and the financial arrangements that have been or will be made to assure that adequate funds will be available to cover these costs at the time of disposal.

22. The licensee shall implement, maintain, and execute the response measures of his Radiological Contingency Plan submitted to the Commission on March 11, 1982. The licensee shall also maintain implementing procedures for his Radiological Contingency Plan as necessary to implement the Plan. The licensee shall make no change in his Radiological Contingency Plan that would decrease the response effectiveness of the Plan without prior Commission approval as evidenced by a license amendment. The licensee may make changes to his Radiological Contingency Plan without prior Commission approval if the changes do not decrease the response effectiveness of the Plan. The licensee shall maintain records of changes that are made to the Plan without prior approval for a period of 2 years from the date of the change and shall furnish the Chief, Uranium Fuel Licensing Branch, Division of Fuel Cycle and Material Safety, NMSS, U.S. Nuclear Regulatory Commission,

Washington, D. C. 20555, and the appropriate NRC Regional Office specified in Appendix D of 10 CFR Part 20, a report containing a description of each change within 6 months after the change is made.

DONALD A. COOL

Donald A. Cool, Ph.D.
Uranium Process Licensing Section
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety, NMSS

Approved by: Original signed by: W. T. Crow
W. T. Crow, Section Leader

U.S. NUCLEAR REGULATORY COMMISSION

FINDING OF NO SIGNIFICANT IMPACT

RENEWAL OF SOURCE MATERIAL LICENSE NO. SUB-1010

SEQUOYAH FUELS CORPORATION
(UF_6 CONVERSION)

GORE, OKLAHOMA

DOCKET 40-8027

The U. S. Nuclear Regulatory Commission (the Commission) is considering the renewal of Source Material License No. SUB-1010 for the continued operation of the Sequoyah Fuels Corporation's (SFC) UF_6 conversion facility at Gore, Oklahoma.

Environmental Assessment

Identification of the Proposed Action: The proposed action would allow SFC to continue operation for another 5 years essentially as it has been operated for the past years. The SFC plant produces high-purity UF_6 using uranium concentrates (yellowcake) as the starting material. The manufacturing process being used includes wet chemical purification to convert yellowcake to pure uranium trioxide followed by dry chemical reduction, hydrofluorination, and fluorination techniques to produce UF_6.

The Need for the Proposed Action: The SFC UF_6 conversion plant is one of only two such facilities in the United States. (The other is at Metropolis, Illinois.) The UF_6 production is one phase of the overall fuel cycle leading to production of fuel elements for nuclear reactors. Currently, the Sequoyah facility supplies UF_6 conversion services for the commercial nuclear power industry.

As long as the current demand for uranium fuel continues, the UF_6 production rate at either of the existing facilities is not expected to decrease. Denial of license renewal for the UF_6 conversion activity at the Gore site would require that similar activities expand at the only other existing UF_6 facility or at a new site. Although denial of renewal of the source material license for this plant is an alternative available to the NRC, it would be considered only if significant issues of public health and safety could not be resolved to the satisfaction of the regulatory authorities involved.

Environmental Impacts of the Proposed Action: The SFC facility at Gore, Oklahoma, has been in operation since 1970. The overall production and impact of this facility from past operations were appraised by NRC in February 1975 and October 1977 in the following references: (1) U. S. Nuclear Regulatory Commission, Final Environmental Statement related to the Sequoyah Uranium Hexafluoride Plant, Kerr-McGee Nuclear Corporation, Docket No. 40-8027, NUREG-75/007, February 1975; and (2) U. S. Nuclear Regulatory Commission, Environmental Impact Appraisal by the Division of Fuel Cycle and Material Safety, October 1977. No significant modifications of the production procedures have been made since the previous environmental assessment. For the current license renewal action, the NRC staff has determined that the scope of the environmental assessment should include: (1) review the operation of the facility during the recent license period by comparing plant operation, effluent releases, and environmental monitoring data with license requirements or permissible levels of environmental contamination; (2) assess the impact on the environment from continued operation of the plant in its current configuration; and (3) discuss the alternatives to the proposed action as required by Section 102(2)(E) of NEPA. The Environmental Assessment (NUREG-1157) applies only to the renewal of the current license. The radiological impacts of the SFC facility were assessed by calculating the maximum dose to the individual living at the nearest residence and to the local population living within an 80-km (50 mile) radius of the plant site. Based on the past monitoring data, the NRC staff had calculated the 50-year dose commitments to the maximally-exposed individual living at the nearest residence (730 m NNE of the plant site); the committed doses are: whole-body - 0.9 mrem; bone - 6 mrem; and lung - 15 mrem. The doses are in compliance with the 25 mrem limits set by the U. S. Environmental Protection Agency for the uranium fuel cycle facilities (40 CFR Part 190). The collective whole-body dose to the population within an 80-km (50 mile) radius of the plant is 2.4 man-rem which is only about 0.005 percent of the population dose of 4.6×10^4 man-rem resulting from the natural background radiation dose in the area. For nonradiological air effluents, the plant complies with the permit requirements issued by the State of Oklahoma. For nonradiological liquid effluents discharged to surface water, SFC is subject to the National Pollutant Discharge Elimination System (NPDES) permit issued by the EPA. Compliance history for past years indicated that SFC is generally in compliance with the NPDES permit except for a few occasional short-term violations. Therefore, the staff concludes that there will be no significant impacts associated with the proposed action.

Agencies and Persons Consulted: The NRC staff met with representatives of the Oklahoma Water Resources Board on May 3, 1983, and the staff also contacted the Oklahoma State Department of Health, Air Quality Service.

Finding of No Significant Impact: The Commission has determined not to prepare an Environmental Impact Statement for the proposed action. Based upon the foregoing Environmental Assessment (NUREG-1157), we conclude that the proposed action will not have a significant effect on the quality of the human environment.

The Environmental Assessment (NUREG-1157) for the proposed action, on which this Finding of No Significant Impact is based, relied on the following environmental documents: (1) Kerr-McGee Nuclear Corporation, Sequoyah Facility License Renewal Application, License SUB-1010, Docket No. 40-8027, September 1, 1982; (2) Kerr-McGee Nuclear Corporation, Response to U. S. Nuclear Regulatory Commission's Site Visit Information Request, July 11, 12, and 20, and August 19, 1983; (3) Sequoyah Fuels Corporation, Sequoyah Facility License Renewal Application (Revised), License SUB-1010, Docket No. 40-8027, October 1983; and (4) Supplemental Environmental Information from Sequoyah Fuels Corporation in letter dated March 15, 1985.

The Environmental Assessment (NUREG-1157) and the above documents related to this proposed action are available for public inspection and for copying for a fee at the NRC Public Document Room, 1717 H Street, N.W., Washington, D.C., and at the Local Public Document Room at the Sallisaw City Library, 111 North Elm, Sallisaw, Oklahoma. Copies of NUREG-1157 may also be purchased by calling

(301) 492-9530 or by writing to the Public Services Section, Division of Technical Information and Document Control, U. S. Nuclear Regulatory Commission, Washington, D.C. 20555, or purchased from the National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Dated at Silver Spring, Maryland this 5th day of September, 1985.

FOR THE NUCLEAR REGULATORY COMMISSION

Original Signed By:
W. T. Crow

W. T. Crow, Acting Chief
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety, NMSS

APPENDIX D

INTRODUCTION

This procedure defines the proper method for filling, sampling, inspecting, moving and shipping UF6 cylinders.

The careful handling of hot liquid UF6 is extremely important: (1) There is potential for serious injury to personnel, (2) there could be a major detrimental impact to the environment, and, (3) the financial loss could be large.

SAFETY PRECAUTIONS

I. Refer to Standard Operating Instructions, G-001, "Health and Safety Precautions and Requirements." In addition, observe the following precautions:

   A. Verify that all emergency equipment is available to control or stop a UF6 release before starting a job.

   B. Always have a dust collector hose ready for use when disconnecting the fill station pigtails and sample bombs.

   C. Lower the cylinder-holding arms onto the top of the cylinder before lifting or transporting the cylinder.

   D. Open all valves slowly, expecting a possible UF6 leak.

II. Refer to Standard Operating Instructions, E-008, for instructions and safety precautions to be taken in the event of a major UF6 release.

QUALITY ASSURANCE

All operations in this procedure are to be done in accordance with the Quality Assurance practices indicated in this procedure and as specified in Quality Assurance procedures QA-001 and QA-002, and additional Quality Assurance-related procedures which may be issued.

PROCEDURE

I. Receiving UF6 cylinders

A. New Cylinders

1. A Cylinder Status Sheet (Form KM-3719-D) is to be filled out for each new cylinder received. A Quality Assurance Inspector must inspect and approve each new UF6 cylinder prior to releasing the cylinder to production for filling. The Inspector's note of approval, including initials and date on the Cylinder Status Sheet, is required. The back side of the Cylinder Status Sheet includes a UF6 Cylinder Inspection Data Sheet.

2. Each new UF6 cylinder must be leak checked prior to filling, by the shipping operator as follows:

a. Pressure the cylinder with air to 70 psig.

b. Soap check for leaks around the valve and plug threads. Check that the valve stem seal does not leak with the valve open. Check that the valve seat does not leak by when the valve is closed. This leak test must be observed by and approved by a Quality Assurance Inspector.

c. Make the appropriate entry on the Cylinder Status Sheet to show that the cylinder has been leak checked.

3. The operator must obtain and record the original tare weight of new cylinders prior to filling:

a. Place the light test-cylinder on the transfer cart, center the cart on the scales, disconnect the air hoses on the cart.

Note: It is important to always have the scale beam locked when moving the cart on or off the scales.

b. Set the scale to read 4503 pounds and adjust as necessary by adding or removing shot. Stamp the weigh ticket and attach it to the Cylinder Status Sheet.

c. Bring in the empty cylinder and tare weigh it. Attach the weigh ticket to the Cylinder Status Sheet. Record the "original" tare weight on the Cylinder Status Sheet. Record the "original" tare weight in the UF6 cylinder weight log book.

Note: The cylinder is to be weighed without the valve cover.

B. Returned Cylinders

1. Record in the shipping operator's log book the cylinder number, date and time received. The operator must sign all log entries. The operator fills out a Cylinder Status Sheet for the returned cylinder.

2. Remove all non-applicable tags and markings.

3. A Quality Assurance Inspector must inspect and approve each returned cylinder prior to releasing the cylinder to production for filling.

4. The Quality Assurance Inspector designates the disposition of the cylinder.

   a. If the cylinder is OK to use, then this is written on the Cylinder Status Sheet in the Remarks section and initialled by the Quality Assurance Inspector.

   b. If the 5-year check is due, then move the cylinder to the storage area for "hydrostatic pressure test due" cylinders.

   c. If not OK to use, then this is written on the Cylinder Status Sheet and a "Danger do not use" tag is put on the cylinder valve. The Quality Assurance Manager is notified of the rejection. The Material Review Board reviews all rejected cylinders and decides on their disposition.

5. Cylinders shall be moved to designated storage areas depending on their disposition.

II. Cylinder Filling and Sampling

A. Inspection Before filling:

Before a cylinder can be filled, the operator must inspect the cylinder and fill out the "prior to filling" inspection data sheet on the back side of the Cylinder Status Sheet. Any cylinder found unacceptable must be tagged and set aside for re-inspection by the Quality Assurance Inspector. The operator must verify that the cylinder meets the following specific requirements:

1. The cylinder must have had previous approval for filling by a Quality Assurance Inspector. Approval is noted in the Remarks section of the Cylinder Status Sheet.

2. The cylinder must not be due hydrostatic testing on the date it is filled. This information is in the tare weight log book.

3. The cylinder plug must be certified. A list of empty cylinders having certified plugs will be maintained in the UF6 scale room.

4. The cylinder valve must have at least one but no more than six exposed (visible) threads. Record the number of visible threads on the Cylinder Status Sheet.

B. Product Draining

1. Move the empty cylinder to the drain station and use the tare bar to set the scale reading at zero. Connect the pigtail. Disconnect the electrical cord from the cart.

2. To pressure check the pigtail connection, leave the cylinder valve closed, close the manual block valves on the secondary and primary drain headers. Open all valves in the line that goes to the UF6 drain filter and pigtail. Hook up the purge air hose to the header. Open the air supply valve first, then open the manual valve in the air line to the header. This will pressure up the header and the pigtail. Close the air valve and observe the pressure gauge in the header. If there is a leak, the pressure will fall. Additionally, leakage should normally be visible by white UO2F2 smoke.

3. If there are no leaks, disconnect the air hose and depressure the header by opening the valve to a primary or secondary cold trap that is under vacuum. Open the cylinder valve and the manual valve in the line from the secondary or primary traps, depending on which trap you are going to drain. Make sure there are no leaks.

4. When the trap is ready to drain, check that all other cold trap drain valves are closed. Open the drain valve on the trap to be drained. Check the pigtail immediately to make sure there are no leaks.

5. Check the scale reading to verify that the trap is draining.

6. Draining must be stopped when the scale reading reaches 100 pounds above maximum allowable, for the cylinder being filled, or the trap runs empty. Close the trap drain valve and the cylinder valve. Line up the header so that you can evacuate back into a primary cold trap that is on the line through the drain valve. Open the cylinder valve and evacuate approximately 100 pounds back out of the cylinder and close the valve.

   Note: Do not heat a cylinder which has been overfilled. Evacuate the overfilled cylinder without heating until the maximum net weight is attained.

This is necessary to prevent rupture of the cylinder due to hydrostatic pressure.

7. After one-half hour (minimum) of evacuation on the drain line, including the drain filter, close all manual valves.

   Note: It is important that the drain filter be evacuated a minimum of 30 minutes to prevent hydrostatic pressure build-up when the filter is isolated.

8. If the trap was emptied and the cylinder is not full, leave it connected until the next trap is ready to drain. If the cylinder is full, disconnect the pigtail and remove the cylinder from the cart.

9. If the cylinder was filled in one draining or in two drainings which were less than four hours apart, it can be sampled immediately. If not, then it will go to the steam chest for 12 hours before sampling.

   Note: Do not heat a cylinder which has been overfilled. Evacuate the overfilled cylinder without heating until the maximum net weight is attained. This is necessary to prevent rupture of the cylinder due to hydrostatic pressure.

10. After filling the cylinder, and before moving the cylinder from the filling station, the operator makes an inspection and fills in the 'after being filled' inspection record.

C. Handling cylinders that contain liquid UF_6

   Note: Extreme caution must be taken when handling liquid UF_6.

1. Verify that the cylinder valve is always in the 12 o'clock position before picking up the cylinder.

2. Never lift the cylinder higher than necessary.

3. Always keep the cylinder as close to the ground as possible while in travel.

4. Always lower the cylinder-holding arms onto the top of the cylinder before lifting or traveling with the cylinder.

5. Always minimize the distance of moving a full cylinder of hot UF_6.

6. Always avoid sudden stops or sharp jerky turns. Hot liquid UF_6 will shift the weight (center of gravity) of the cylinder from one point

to another, whereas cylinders with cold solidified UF_6 are stable.

D. Sampling

1. Roll the cylinder over so that the valve is in the 9 o'clock position.

   Note: Be sure to use the cylinder turning mechanism on the cylinder cart to turn the cylinder to the 9 o'clock position.

2. Connect the sample bomb and open the valve on the bomb.

3. Use a heat tape or a heat gun to prevent freezing of the connection.

4. Open the cylinder valve very cautiously about one-half to one turn and feel the sample bomb to see that it is getting hot. Leave the cylinder valve open approximately 15 seconds.

5. Cool the sample bomb with cool water and then close the sample bomb valve.

6. Disconnect the sample bomb and weigh it immediately.

   a. If the weight is between 300 and 2100 grams of UF_6, label the sample and take it to the lab.

   b. If below 300 grams, hook the bomb back to the cylinder and repeat Steps 3, 4, and 5.

   c. If over 2100 grams, get a new sample bomb from the lab and start over. This time, leave the cylinder valve open for a shorter period of time. Refer to Step 4.

      Note: The over-weight sample must be evacuated without heating the sample bomb until the net weight of UF_6 is less than 2100 grams. This is done to prevent rupture of the sample bomb due to hydrostatic pressure.

7. After sampling, set the cylinder out on the storage pad for cooling. Be sure to place the cylinder so that the cylinder valve is in the 12 o'clock position while the cylinder contents are cooling and solidifying.

III. Replacing cylinder parts

A. If any cylinder part needs replacing, for any reason, the replacements must be noted on the Cylinder Status Sheet with the following information required.

1. Name of part and lot designation

2. Reason for replacement

3. Date replaced

4. Person who replaced part.

B. Disposition of replaced parts

1. The replaced part must be marked and held in a designated area for disposal under the direction of the Quality Assurance Department.

2. The Materials Review Board will specify disposition of replaced parts.

IV. Preparing Cylinder for shipment

A. A cylinder can be prepared for shipment when the following conditions are met:

1. The cylinder must have cooled a minimum of five days to insure solidification of contents.

2. The molybdenum content must be less than 1 ppm.

3. The chromium content must be less than 8 ppm.

4. The vacuum on the cylinder must be greater than 10 inches of mercury.

5. Cylinder weight requirements:

Cyl size (Tons)	Min. net Wt. (lbs.)*	Max. net Wt. (lbs.)	Max. gross Wt. (lbs.)
2.5 A,B	4,800	A=4950 B=5020	not applicable
10	20,030	21,030	25,500
14	26,000	27,560	not applicable

6. Vapor pressure (at 200 F) must not exceed 75 psia.

a. If vapor pressure is 65-69 psia, evacuate the cold cylinder for o... ·our or until 100 pounds have been evacuated.

b. If vapor pressure is 70-74 psia, heat the cylinder six hours and evacuate out 100 pounds over a one hour period.

c. If vapor pressure is 75 psia or above, reheat the cylinder for 12 hours. Then evacuate out 200 pounds over a one hour period and resample.

B. Final Weighing

1. Put the proper full-test cylinder on the cart and weigh it. (14, 10, or 2.5 ton). The weight should be within +/- 3 pounds of the test-cylinder weight. If it doesn't, contact the shift supervisor. If it does, record the weight on the Cylinder Status Sheet and stamp the ticket.

2. Put the full cylinder on the scale and weigh it. The cylinder valve must be capped. (Weigh the cylinder without the valve cover.) Record the weight on the Cylinder Status Sheet and stamp the ticket.

3. If the cylinder weight and other specifications in IV.A. above are met, set the cylinder on the shipping pad.

4. Put the Cylinder Status Sheet and weight tickets in the Area Supervisor's mail basket in the control room after the Shift Supervisor has signed it.

5. The Area Supervisor will verify the results for molybdenum, chromium and vapor pressure and will approve the Cylinder Status Sheet.

6. The Production Manager will approve the Cylinder Status Sheet and forward it to the Quality Assurance Manager.

7. The Quality Assurance Manager will forward the approved Cylinder Status Sheet to Accounting.

V. UF_6 Cylinder Shipping

A. The Accounting Department will notify the Area Supervisor at least two weeks in advance of cylinder shipments. Notification will be accompanied by the Cylinder Status Sheets for the cylinders to be shipped.

B. The Area Supervisor will place the Cylinder Status Sheets in the "Scheduled Shipments" file in the scale room at least one week in advance of shipment. Any recheck requirements will be noted on the Cylinder Status Sheet.

C. The shipping Operators must recheck cylinders as required by the Area Supervisor and arrange cylinders for truck loading as scheduled.

D. The Quality Assurance Inspector observes the check of the cylinder vacuum, and makes a final check of the valve just before the valve cover is put in place. The Quality Assurance Inspector attaches a wire seal on the valve cover bolts.

E. Truck Loading

1. Pull the Cylinder Status Sheets on cylinders scheduled for shipment.

2. Load the cylinders on the truck. (Recheck cylinder numbers.)

   Note: Always load cylinders so that the cylinder valves are toward the rear of the truck.

3. The driver will secure the cylinder to the truck with the tie-downs.

4. Inspect the cylinder after loading, and fill out the "After loading" inspection data sheet on the back side of the Cylinder Status sheet. Note on the Cylinder Status Sheet if the QA seal is intact on the valve cover.

5. Verify that the truck has proper shipping placards installed, such as "Radioactive - Low Specific Activity".

6. Place the Cylinder Status Sheets in the Area Supervisor's mail box after the Shift Supervisor has reviewed and initialed them.

7. The Area Supervisor will initial and then forward the Cylinder Status Sheets to accounting.

[signature]
Quality Assurance Manager

1/28/85
Date

[signature]
Facility Manager

1/28/85
Date

INTRODUCTION

This procedure establishes the method for washing, inspecting and hydrostatic testing of UF6 shipping cylinders. It is a requirement of the NRC that UF6 cylinders be hydrostatically tested and inspected internally and externally once every five years. (Exception: If a cylinder is full at the five-year inspection time, it need not be inspected until that cylinder has been emptied by the customer, and shipped back to the facility. This cylinder must not be refilled until it has been hydrostatic-tested and inspected.)

SAFETY PRECAUTIONS

I. Refer to the General Operating Instructions, G-001, Health and Safety Precautions and Requirements.

II. Wear a face shield and rubber gloves while working on the cylinder cleaning portion of the procedure.

III. The material washed from a cylinder will contain HF acid unless it has been neutralized. Extreme caution should be taken to avoid contact with the skin or eyes. Treat HF burns immediately.

IV. Be sure to use a lock pin on all hose coulpings. Securely anchor the discharge end of the drain hoses. Hoses should be thoroughly flushed with water after use and stored properly.

QUALITY ASSURANCE

All operations in this procedure are to be done in accordance with the Quality Assurance practices indicated in this procedure and as specified in Quality Assurance procedures QA-001 and QA-002, and additional Quality Assurance-related procedures which may be issued.

PROCEDURE

I. Cylinder Washing

A. Determine which cylinder is to be washed or tested. Locate the cylinder and start a Cylinder Cleaning and Testing Status Sheet for it.

B. Move the cylinder to the cylinder preparation area.

C. Carefully open the cylinder valve to verify that the cylinder is not under pressure. If the cylinder is under pressure, it must be taken to the UF6 filling station so that the cylinder may be evacuated into the plant UF6 vacuum system. If the cylinder is under a vacuum, then close the valve.

D. Remove the cylinder plug and install the dip leg discharge valve.

Note: The used cylinder plug is to be put into a designated container for disposal. Plugs are not to be re-used.

E. Set the cylinder on the washing station with the fill valve to the south. Install the valve connector and transfer hose from the solution pressure tank.

F. For a cylinder heel not exeeding 25 pounds, add 70 gallons of water and 20 pounds of soda ash to the solution tank. Heat the solution to approximately 140 F. Then bubble air through the solution to get it thoroughly mixed. For any cylinder heel over 25 pounds add approximately one pound of soda ash for each one pound of heel. Above 50 pounds, see the Area Supervisor for instructions.

G. Pressure the solution tank with air to 30-40 psig, and open the proper valves to transfer to the cylinder.

H. Close the cylinder valve when the transfer is completed. Bleed off the pressure from the solution tank, and remove the hoses from the cylinder.

I. Start the cylinder wash rotation. Operate 10 minutes level, five minutes tilted 16 degrees angle to the south, and then five minutes at 16 degrees angle to the north.

J. While the cylinder is being washed in Step H., the rinse solution batch can be prepared. The rinse solution batch is to be the wash solution for the next cylinder. See Step F.

K. Stop the cylinder rotation with the discharge valve dip leg at the low point.

1. Reconnect the air supply hose to the inlet valve.

2. Connect a hose to the discharge valve and to the transfer line to the digesters.

3. Tilt the cylinder about 10 degrees to the north and check line and valve for transfer to the digesters.

L. With care, sample the solution for pH, which should be above 6. If the pH is below 6, more soda ash solution should be added to the wash solution to raise the pH. If the pH is above 6, the wash solution should be discharged to the digestors. Check the digester level before transferring.

M. Open the discharge valves and the cylinder inlet valve and pressure with air to 30-40 psig to complete the transfer.

N When the transfer is completed, close the air supply and allow the cylinder to depressure.

O. Close the discharge and transfer line valves and remove the discharge hose.

P. Pressure the solution tank to 30-40 psig, and open the proper valves to transfer the rinse solution into the cylinder.

Q. Close the cylinder valve and bleed off the solution tank pressure, and then remove the hoses from the cylinder.

R. Start the cylinder rinse rotation. Operate five minutes level, five minutes tilted 16 degrees angle to the south and then five minutes 16 degrees angle to the north.

S. Stop the rotation with the discharge valve dip leg at the low point. reconnect the air hose to the cylinder valve, and the discharge valve hose to transfer the rinse solution back to the solution pressure tank.

T. Open the proper valves to complete the transfer using 30-40 psig air.

U. Close the air valve and the cylinder inlet valve. Switch the hose to steam.

V. Open the cylinder inlet valve and open the steam valve to steam out the cylinder for 15 minutes. (If the cylinder is being cleaned only and not tested, continue the steam-out for one hour total time and skip to Step II. I.).

W. Close the steam valve, allow the cylinder to depressure, and then disconnect the hoses from the cylinder. Move the cylinder to the cylinder preparation area with the inlet valve at the high point.

II. Hydrostatic test

A. Prior to the hydrostatic test, perform a 'soap test,' as described in III. E.1. to 4., as a check on the soundness of the valve and plug couplings.

B. Loosen and open the cylinder inlet valve, reconnect the water hose to the discharge valve and start the water fill for the hydrostatic test. The water used to test the previously tested cylinder will be transferred to this cylinder. It normally takes about 45 minutes to an hour to fill the cylinder, so another cylinder can be handled on the wash station while this cylinder is filling. Stop the water when the inlet valve starts to spill water.

C. Reposition the cylinder back on the wash station and install the two tie-down straps. Tilt the cylinder north and place the support jack under it.

D. Water fill until all the air is displaced from the cylinder.

E. Hook up the connections for the hydrostatic test pump and bleed off all air.

F. Pressure the cylinder to 400 psig for 30 minutes. Make an external cylinder surface inspection for cracks, defects, etc. See the attached Figures 1 and 2. Have the Quality Assurance Inspector verify that the hydrostatic test is OK and so note on the Cylinder Cleaning and Testing Status Sheet. Bleed off the pressure.

G. Remove the hydrostatic test pump connection, reinstall the inlet valve with the hose connection. Remove this cylinder from the wash station to the preparation area cylinder cradle. Position the cylinder on the cradle.

H. Hook up the proper hoses so the water in this cylinder can be pressured out with air and in to the next cylinder to be tested (also in the preparation area in a cradle). Make the transfer. (Normally another cylinder can be washed on the wash station during this time.)

I. After all the water is transferred out, hook up steam to this cylinder and steam for one hour allowing the condensate to dump to the sewer drain. After one hour of steam heating the cylinder shell temperature should be very close to 212 degrees F. (Condensate from cylinders that are washed only should be discharged to the solution pressure tank).

J. Switch the cylinder to an air purge for 30 minutes to dry the cylinder inside. If an ejector is available, the air operated ejector may be used (instead of the air purge) to pull a vacuum on the cylinder. The water inside should flash out to dryness in about 15 minutes.

K. Remove the valve stem. Inspect the inside of the valve for distortion and corrosion. If necessary, replace the valve in step III. D. With the special inspection light inside the cylinder, make a thorough internal inspection with the Quality Assurance Inspector. The Quality Assurance Inspector is to sign the Cylinder Cleaning and Testing Status Sheet if the cylinder is OK.

L. If there is any loose sludge or scale material remaining in the cylinder, move the cylinder to a vacuum station. With the special vacuum tube, vacuum all the material out of the cylinder until clean.

III. Re-assembly

A. Clean the threads of the cylinder couplings at the valve and plug ends. Run a thread die tap in the valve coupling to verify that the threads are straight and true.

B. Obtain a valve, if necessary, and plug to install in the cylinder.

Record the identification of each on the Cylinder Cleaning and Testing Status Sheet. Also record the identification of any parts intalled in the valve.

C. The plug, which is newly tinned, and has not been previously installed, must be turned in a minimum of five threads on the plug, but must have two full threads minimum showing outside the coupling.

D. The valve, if replacement is made, is newly tinned and must not have been previously installed. Verify that the packing nut is tight. It must be turned in (engaged) a minimum of seven threads and must not exceed an engagement of 12 threads. The valve must be torqued in by using a minimum of 200 foot-pounds but not to exceed 400 foot-pounds of wrench torque. The valve must meet these NRC specifications or be replaced with one that does. See Figure 3.

E. After the plug and valve are reinstalled, the cylinder is pressured to 70 psig with dry air and "soap tested" for possible leaks using soap solution.

1. With the cylinder valve closed, soap the threads, valve stem, packing nut threads and make a bubble over the valve discharge port for possible leakage.

2. Install the valve discharge cap and open the valve 50% open. Soap the valve stem, packing nut threads and the discharge port threads for possible leakage.

3. If there is no leakage, the valve and plug are OK. Be sure to rinse off the soap solution with water when the test is completed.

4. If the soap test is OK the Quality Assurance Inspector signs the Cylinder Cleaning and Test Status Sheet, and stamps the month and year on the cylinder identification plate.

5. If the soap test is not OK, then the part which is leaking is reinstalled and checked as in III.E. above.

F. Open the cylinder valve and allow all the air to vent off.

G. Tare weigh the test weight cylinder and this cylinder for final weight on the Cylinder Cleaning and Testing Status Sheet.

H. Verify that the inspector has stamped the cylinder and has OKed it. Be sure to fill out the log book each day and complete each Cylinder Cleaning and Testing Status Sheet before turning it in to the Area Supervisor.

I. Move the cylinder to a holding area until the shipping area supervisor issues a process status sheet for filling, then move it into the processing area storage.

J. The completed Cylinder Cleaning and Testing Status Sheet is approved by the Production Manager and then forwarded to the Quality Assurance

Manager for approval. The Quality Assurance Manager gives the Cylinder Cleaning and Testing Status Sheet to Accounting for filing.

Quality Assurance Manager — Date: 4/17/84

Facility Manager — Date: 4/17/84

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

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SEE INSTRUCTIONS ON THE REVERSE

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Sequoyah Fuels Facility, Gore, Oklahoma, January 4, 1986

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4. DATE REPORT COMPLETED

MONTH	YEAR
February	1986

5. AUTHOR(S)

R. D. Smith
C. L. Cain
R. Chappell

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11a. TYPE OF REPORT

Investigation Report

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12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

At 11:30 a.m. on January 4, 1986, a Model 48Y UF_6 cylinder filled with uranium hexafluoride (UF_6) ruptured while it was being heated in a steam chest at the Sequoyah Fuels Conversion Facility near Gore, Oklahoma. One worker died because he inhaled hydrogen fluoride fumes, a reaction product of UF_6 and airborne moisture. Several other workers were injured by the fumes, but none seriously. Much of the facility complex and some offsite areas to the south were contaminated with hydrogen fluoride and a second reaction product, uranyl fluoride. The interval of release was approximately 40 minutes.

The cylinder, which had been overfilled, ruptured while it was being heated because of the expansion of UF_6 as it changed from the solid to the liquid phase. The maximum safe capacity for the cylinder is 27,560 pounds of product. Evidence indicates that it was filled with an amount exceeding this limit.

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Uranium, uranium hexafluoride, hydrogen fluoride, airborne release, cylinder rupture.

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