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by ANL/ED/CP--89379

K. E. Rosenberg, W. W. Benjamin, C. J. Knight, J. A. Michelbacher

Argonne National Laboratory-West
P.O. Box 2528
Idaho Falls, ID 83403-2528

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K. E. Rosenberg, W. W. Benjamin, C. J. Knight, J. A. Michelbacher

Argonne National Laboratory
P. O. Box 2528
Idaho Falls, Idaho 83403-2528
(208) 533-7040

ABSTRACT

A glovebox was designed, fabricated and mocked-up for the Waste Isolation Pilot Plant (WIPP) Gas Generation Experiments (GGE). The experiments are being conducted at Argonne National Laboratory-West (ANL-W).

These experiments will determine the gas generation rates from materials in contact handled transuranic (CH-TRU) waste at likely long term repository temperature and pressure conditions. The long term conditions are simulated by the use of seven and a half liter test containers contained in an inert atmosphere glovebox. The test containers allow for regular sampling of the headspace gases which are analyzed to determine the quantity and types of gases generated over time.

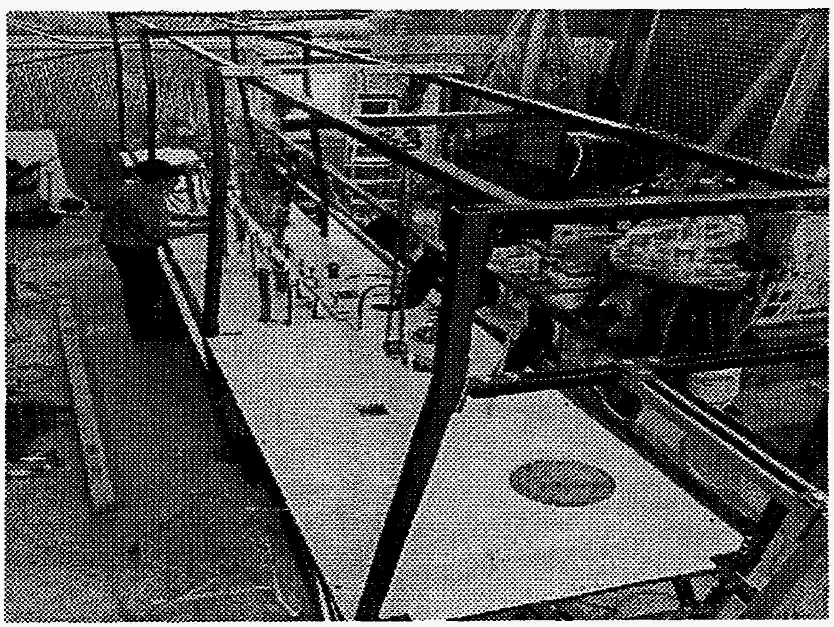
The test containers, associated instrumentation, sampling loops, and delivery lines are housed in the argon atmosphere glovebox. This inert atmosphere is provided to maintain and assess the integrity of the gas sampling system and test containers, and to efficiently monitor the test parameters for the GGE. In an inert atmosphere, oxygen contamination of the sampling containers through diffusion processes is minimized. More importantly, the inert atmosphere reduces the potential contamination of the sampling system, which is essential for characterization of the gases generated during the experiment.

Research and development (R&D) of the gas sampling systems and other test container support systems was performed prior to their inclusion into the glovebox. The customer's schedule did not permit time for performing R&D of the support systems, designing the glovebox, and fabricating the glovebox in a serial fashion. In order to meet the aggressive schedule, a parallel approach to these specific tasks was undertaken. As R&D of the sampling system and other support systems was initiated, a detailed specification was written concurrently by ANL-W for contracting a manufacturer to design and build the glovebox and support equipment. The specification was written such that the contractor had the full understanding that the

R&D being performed at ANL-W would add additional functional requirements to the glovebox design. The design/build specification was written such that the contractor could proceed with structural designs while ANL-W was performing R&D of certain systems.

Initially, the contractor had sufficient information to design the glovebox shell. Once the shell design was approved, ANL-W built a full scale mockup of the shell out of plywood and metal framing at the ANL-W Engineering Lab. The full scale mockup is shown in Photograph 1. Support systems were mocked up and resultant information was forwarded to the glovebox contractor to incorporate into their design. This parallel approach resulted in a glovebox being delivered to ANL-W on schedule and within budget.

PHOTOGRAPH 1



BACKGROUND

Argonne National Laboratory was selected by the Department of Energy Carlsbad Area Office (DOE-CAO) to conduct Gas Generation Experiments using Contact Handled Transuranic (CH-TRU) waste.

The GGE objective is to measure the rates and species of gas generated from

CH-TRU waste immersed in brine. The brine is chemically similar to intergranular brines found in areas such as the Solado Formation and the Nash Draw which are located in and around the Waste Isolation Pilot Plant (WIPP). Major gas generation processes expected in WIPP disposal rooms include corrosion, microbial activity, and radiolysis. The GGE program will measure gas-generation rates at anticipated WIPP temperatures and pressures. Results will be used to evaluate synergistic gas generation mechanisms and a gas generation model. The gas generation model will be used by the WIPP performance assessment team to evaluate compliance with the Environmental Protection Agency's 40 CFR 191. The tests started in January 1996 and will run for an anticipated time period of 3 to 5 years.

The GGE will simulate the actual conditions at the WIPP facility using pressure vessels otherwise known as test containers. The test containers are used for waste and brine emplacement. Initially, the test containers are pressurized to approximately 14.6 MPa in order to simulate the lithostatic pressure at the WIPP facility. The test containers are 7.5 liters and are designed and fabricated to ASME Boiler and Pressure Vessel Code Section VIII. Each test container is made from corrosion resistant Hastelloy C276 to preclude contribution to the gas generated in the test container. Reference (1) provides a complete description of the test containers.

The experiment is housed in an inert atmosphere glovebox for two primary reasons: (1) to simulate the actual conditions at the WIPP as described below and (2) to maintain and assess the integrity of the gas sampling system and test containers and to efficiently monitor the test parameters for the GGE. In an inert atmosphere glovebox, contamination of the test container atmospheres through diffusion processes is minimized. More importantly, the inert atmosphere will reduce the potential of contamination of the sampling system, which is essential for the accurate determination of oxygen, nitrogen, and carbon dioxide levels in the test container. In addition, the argon atmosphere in the glovebox will be used to determine the presence of gas leakage into the sampling system over the test period.

The glovebox is sized to hold twenty-four test containers. Each test container is designated to contain a specific mixture of waste and brine. To provide the functions necessary for the experiment each test container has six ports located on its head. Table 1 describes the purpose of each port.

TABLE 1
TEST CONTAINER PORTS

Port Name	Purpose
Brine Addition Port	Brine addition
Rupture Disk Port	Rupture disk is required for ASME pressure vessels
Gas Port	Headspace gas sampling and pressure monitoring

Temp 1 Port	Temperature measurement of waste/brine mixture during the experiment
Temp 2 Port	Temperature measurement of brine as it is initially added to container
Sparge Port	Removal of oxygen from test container after the addition of brine

SCOPE

The glovebox, test containers, and the experiment support systems had to be designed, fabricated, and installed in a timely fashion in order to meet the required schedule. A majority of the support systems for the GGE required research and development (R&D). These support systems had to interface with the glovebox in an ergonomic fashion. In order to support the aggressive schedule, ANL-W was required to design the glovebox and support systems in parallel. This parallel effort was implemented into the construction contract between the design/build contractor and ANL-W. Once the contract was approved, the contractor was instructed to design the shell based on the functional requirements provided. Upon approval of the shell design, the contractor was instructed to initiate fabrication. Directly after shell design approval, ANL-W built a full size rendition of the glovebox shell from plywood and metal framing for the purpose of conducting research and development of the support systems. The glovebox contractor was aware that the research and development work on the support systems would likely change the layout of the gloves and penetrations but not the shell.

Reference (2) gives a complete description of the glovebox support systems.

The size and amount of test containers were established up front and this information was passed on to the contractor. A critical unknown factor at the beginning of the design phase was the height of the instrumentation on top of the test containers. The glovebox contractor was instructed to maximize the distance from the top of the test container to the ceiling of the glovebox, while taking into account the height limitation imposed by the room ceiling. The final glovebox shell dimensions are approximately 703 cm long by 110 cm wide by 285 cm high.

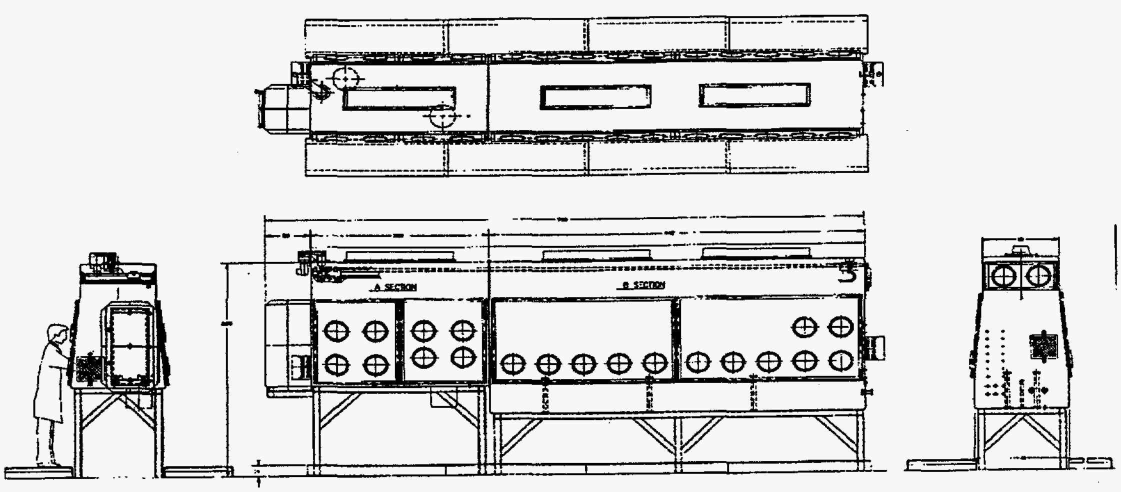
In order to expedite the construction of the glovebox, ANL-W made the research and development of the support systems a priority. As design of the support systems was solidified, the information was passed along to the contractor in an expeditious manner. Using this system, cost changes were minimized due to the minimal amount of re-work that had to be performed. The following sections discuss the mockup/R&D effort of various support systems and how they affected the fabrication/installation of the glovebox.

REMOVABLE TRAYS

The glovebox consists of an "A" and "B" section. See Figure (1). The "A" section consists of the transfer port and maintenance area. The "B" section consists of the twenty-four permanent test container locations and the sampling system area. In order to accommodate the depth of the test container, the "B" section floor is lower than the "A" section floor and a removable false floor was added to the "B" section. This provides a continuous working surface from the "B" section to the "A" section. The removable false floor consists of steel trays, otherwise known as working trays.

The working trays perform several functions. They provide the operators a working surface for obtaining headspace samples and other test container activities. Also, the working trays protect all equipment located below their level, such as the heating system, rupture disk lines, pressure transducer penetration, and test container temperature penetrations. The tray was placed at a height relative to the gloves such that tools and other equipment could be retrieved in a ergonomic fashion. ANL-W mocked up the orientation of the working trays in the Engineering Lab. The mockup consisted of performing several tests. One test performed consisted of ensuring that the working tray could be lifted and clear a permanently installed test container. In addition, all holes in the working tray were mocked up relative to their intended function. Once finalized, this information was passed on to the glovebox contractor for fabrication.

FIGURE 1
GLOVEBOX CONFIGURATION



MAINTENANCE STAND

A maintenance stand was installed in the "A" section of the glovebox and services only one test container at a time. The maintenance stand serves several purposes which include the following operations:

1.) Leak testing of a test container
2.) Sparging operation
3.) Pressurization of a test container
4.) Brine filling, and
5.) Torquing of the test container head bolts

All of these operations were mocked up and an optimum configuration for the maintenance stand was determined. The glovebox contractor was given the mock up results and the information was incorporated into the glovebox design.

SAMPLING SYSTEM

The gas sampling system was fully designed and fabricated using the mock-up glovebox at ANL-W. In addition to fabrication, the sampling system was characterized to minimize the time required for system check out once placed in the glovebox. The system was characterized for pressure and pump-down time because of the five foot distance between the system pressure indicators (cold cathode and thermocouple) and the location of the test container maintenance stand. As a part of test container qualification, every test container head space was sampled for oxygen content while the test container was located in the maintenance stand.

The characterization test helped determine the relationship between the pressure measured by the system pressure indicators and the actual pressure downstream of the test container sampler filter (located between the primary and secondary valve). During the test, 0.4 and 0.5 micron filters were installed between the primary and secondary valves. The valves were individually connected to the end of one of the flexible hoses located on one of the southern most risers. A thermocouple and cold cathode gauge were connected to the other end of the valves. During the test the system was evacuated until the pressure indicated downstream of the sampler valves was adequate to meet gas sampling criteria. The time required to evacuate the sampler to the correct pressure and the difference between the indicated pressures were recorded and incorporated into the gas sampling operation procedure. It was also through this test that the 0.4 micron filter was chosen because of its superior flow characteristics. The system was disassembled, then reassembled in the actual glovebox without any degree of difficulty. **(Need PID)**

HEATING SYSTEM

A heating system was required to keep the test container internals at 30 ± 5°C. The test container "Temperature 1" port contains a Resistance Temperature Device (RTD) which measures the temperature of the internals and feeds the information to a Data Acquisition System. The heating system consists of heating elements in an insulated jacket that surrounds the test container. Redundant heaters were placed in the jacket in case of primary heater failure. The heaters were controlled with a digital controller that resided in the glovebox under the working trays to avoid accidental breakage. Plexiglas covers the controller display for operator viewing . The system was mocked up in the Engineering Lab with simulated waste and brine residing in a test container. After several iterations of testing, a final configuration of the jacket assembly was established. This information was passed on to the glovebox contractor to allow them to initiate fabrication of the heater jackets. This information also established the final configuration of the working trays which the contractor was responsible for fabricating.

In support of the heater system installation, ANL-W built all of the controller supports and wired all of the controllers. The system was installed into the actual glovebox with relative ease and minimal time.

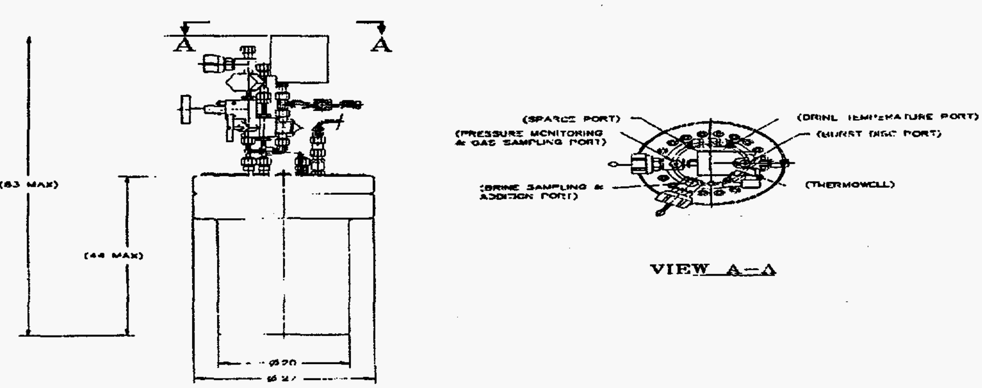
GLOVES

The glovebox requires the use of several gloves. To check glove location and function, ANL-W mocked up most activities that were to be performed in the glovebox, such as obtaining a sample, torquing the test container head bolts, and calibrating the pressure transducers. From the tests, an optimum height was determined. Due to the different functions being performed in the "A" section and "B" section, glove heights were determined to be different. This information was passed on to the glovebox contractor for incorporation into the final design.

TEST CONTAINER INSTRUMENTATION

Each test container has six ports. See Table 1 for description of the six ports. Some ports serve more functions than described by the name designation. The entire assembly of the test container instrumentation was called the "Christmas tree". Figure 2 shows a Christmas tree orientation for one test container. Mockup of the configuration and orientation of the Christmas tree was performed for several reasons including (1) ease of obtaining a sample, (2) interface with the overhead handling system, (3) interface with the support systems such as rupture disk system, pressurization system, sparging system, and brine fill system and (4) other miscellaneous tasks. This portion of the mockup proved to be the most tedious due to the amount of hardware in the Christmas tree and the limited space available. The space was limited due to (1) height of the leak test chamber, (2) height of glovebox ceiling, and (3) reach of gloves. All of the above factors had to be considered during the mockup. After the mockup was complete and a final configuration established, the Christmas trees were built for all of the test containers and were hydrostatically tested independent of the test containers. Mockup of the Christmas tree allowed fabrication and testing prior to the arrival of the actual glovebox.

FIGURE 2
TEST CONTAINER CHRISTMAS TREE ORIENTATION



RUPTURE DISK SYSTEM

Each test container possesses a rupture disc. In case of rupture disk failure, a line downstream of the rupture disk ties into a main header. Each line contained a check valve to prevent backflow. The main header exits the glovebox and is routed to the suspect exhaust system. In order to expedite installation, the system was built in the mockup glovebox and hydrostatically tested. The rupture disk system fit into the glovebox without any problems. The mock-up and design of the rupture disk system resulted in only four welds being performed in the field. The mockup largely reduced the time for final testing in the actual glovebox.

OVERHEAD HANDLING SYSTEM

An overhead handling system was required for glovebox operation. The overhead handling system required six degrees of freedom (up/down, back/forth, left/right relative to an operator). Once the glovebox contractor designed this system, ANL-W mocked it up, ensuring that there was adequate clearance for moving a test container with a full Christmas tree installed on the head. Test container operation requires the test container to be moved down the center of the glovebox. Due to the limited clearance when moving a test container, the center of the glovebox had to be clear of equipment. This was taken into account in the design and mockup of the glovebox support systems. All of this work was performed prior to the arrival of the actual glovebox.

ELECTRICAL BOXES, RECEPTACLES AND INSTRUMENT PENETRATIONS

Several electrical junction boxes, receptacles, and instrument penetrations were required to be installed in the glovebox. The junction boxes and receptacles had to be accessible to the operator but also could not inhibit the daily operations. ANL-W mocked up the locations of these boxes and supplied the information to the contractor for fabrication and installation. Each test container required one penetration for its pressure transducer and RTD. A total of forty-eight instrument penetrations were required based on twenty-four test containers. The locations of these penetrations were mocked up for ease of electrical lead installation and replacement. This information was passed onto the glovebox contractor for incorporation into the final design.

BRINE ADDITION SYSTEM

Brine and inoculum were added to the test container to simulate WIPP long term conditions. The addition of the brine produced a headspace measuring 10% by volume. A brine level indicator is temporarily installed on the test container head during the filling operation. A remote annunciator indicates to the operator when the proper height has been obtained. The brine addition system also consists of a peristaltic pump, reservoir for the brine and a stirring mechanism. The stirring mechanism keeps the inoculum in solution during the fill stage. All of this equipment is located in the maintenance area of the glovebox. The system was mocked up in the Engineering Lab to ensure its operability and fitup relative to the other systems in the glovebox. The system was then fabricated at ANL-W and transferred into the actual glovebox with minimal difficulty.

SPARGING

During test container setup, a brine solution was added to a test container which inundates the waste, leaving a 10% gaseous headspace by volume. The brine addition work is accomplished with the test container in the maintenance stand. Once the test container is filled, the waste/brine mixture is sparged with nitrogen for twenty-four hours in order to reduce the oxygen levels in the test container to less than 100 ppm. The reduced oxygen levels simulate the eventual long term conditions at the WIPP. A test container headspace sample has to be taken to verify the 100 ppm level. The sparging system interfaces with the pressurization/vent system for the nitrogen source gas. The mock up of this system initially showed backstreaming of oxygen into the test container resulting in oxygen levels being greater than 100 ppm in a headspace gas sample. As a result, a mass flow controller was added to the system and the oxygen levels in the test container were reduced to less than 100 ppm. Mockup of the system demonstrated that special penetrations had to be located in the glovebox in order to accomplish the sparging. The results of the mock up were forwarded to the glovebox contractor for incorporation into the final glovebox.

BAG-OUT SYSTEM

A bag-out system is required in the glovebox for the removal of contaminated items and test containers at the end of their testing phase. The test containers will be transferred to another facility, opened up, and their contents characterized. The location and configuration of the bag-out system had to be determined. ANL-W mocked up all of the operations associated with the bag-out system and determined an optimum configuration and location. This information was forwarded to the glovebox contractor for implementation into the final design.

PRESSURIZATION AND VENT SYSTEM

The criteria established for the GGE required the test containers to be pressurized to 14.6 MPa. Additional requirements mandated that at any time during the test phase, the pressure in a test container may have to be increased/decreased and the test container could not be moved once it was in its permanent test location. A pressure/vent system was designed to implement these requirements. Based on the shell configuration, ANL-W fabricated the pressurization/vent system and hydrostatically tested the welds. This was predominately a welded system, designed to be installed into the glovebox with minimal rework of joints. The pressurization/vent system fit into the glovebox without any complications.

PLATFORM

The height of the glovebox required that the operators stand on a platform. ANL-W mocked up the configuration of the platform and determined an optimum height. This information was forwarded to the glovebox contractor to incorporate into the platform design.

TEST CONTAINERS

As described previously, the test containers were supplied with six ports. Four of the ports had metal to metal high vacuum/high pressure fittings welded directly to the head. The metal to metal high vacuum/high pressure fittings were manufactured by the test container fabricator. Instrumentation and fittings were hooked up directly to the VCR fittings. The test containers were required to be leak tight to 1×10^{-7} cc/sec at 17.2 MPa of nitrogen. Qualification of the test container showed the manufacturer met this requirement.

Once the test containers were received at ANL-W, an additional leak test was performed with all of the instrumentation installed up to the first isolation valve. ANL-W's leak checks demonstrated that the metal to metal fittings did not meet the established leak rate criteria. It was determined that during the manufacturer leak test, the metal to metal fittings were overtorqued which damaged the metal seat and that the metal seats were not electropolished as required by the technical specification. As a result of the testing and inspection, ANL-W sent the test containers back to the manufacturer for rework. After the electropolishing, the test containers passed the leak test at both the manufacturer's facility and ANL-W. If it were not for the mock up program set up at the Engineering Lab, a large delay would have resulted in the GGE due to the metal to metal seat problems.

GLOVEBOX CONTROL CABINETS

The stringent sampling criteria required the glovebox to contain an inert atmosphere. To maintain atmosphere integrity, a purification system was purchased by the glovebox contractor and had to be interfaced with the glovebox. Also, a glovebox control cabinet had to be built housing a secondary pressure control system, oxygen monitor, moisture monitor, nitrogen monitor, and alarm systems. Both of these cabinets had to be located close to the glovebox for operator viewing. ANL-W mocked up the physical location of the two cabinets relative to the glovebox and instructed the glovebox contractor on the locations of the cabinets. Location of the cabinets was critical because of the site and number of support gas lines required. The piping between the cabinets and the glovebox ranged from 1/4" flexible tubing to 3" copper pipe.

GAS CHROMATOGRAPH

A gas chromatograph (GC) is required to analyze headspace samples taken from the test containers. The GC had to be located as close as possible to the glovebox sampling station in order to minimize the tubing length between the sampler and the GC. The GC was mocked up at the Engineering Lab and an optimum location and glovebox penetration size and location were determined. The location of the GC affected the location of the glovebox pressure control cabinet and purification system. This information was then forwarded to the glovebox contractor for incorporation into the following designs: (1) fabrication of the glovebox pressure control cabinet, (2) positioning of tubing from the glovebox to the pressure control cabinet, and (3) piping location between the glovebox and the purification system.

CONCLUSION

The GGE was brought on line per the required DOE schedule. If a serial process of fabricating the glovebox, fabricating support systems, installing support systems, and testing support systems was undertaken, the GGE would not have been brought on line as per the required schedule. The mockup of the glovebox and the support systems greatly reduced the time required for bringing the GGE on line. The parallel approach undertaken produced a product that met the DOE functional requirements from a technical standpoint and met the required schedule. The design/build/mockup approach was looked upon as a success by DOE and ANL-W management and will be implemented in applicable future projects at ANL-W.