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A Pneumatic Transfer System for Special Form ^{252}Cf

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Abstract

A pneumatic transfer system has been developed for use with series 100 Special Form ^{252}Cf. It was developed to reduce the exposure to personnel handling sources of ^{252}Cf with masses up to 150 μg by permitting remotely activated two-way transfer between the storage container and the irradiation position. The pneumatic transfer system also permits transfers for reproducible repetitive irradiation periods. In addition to the storage container equipped with quick-release fittings, the transfer system consists of an irradiation station, a control box with momentary contact switches to activate the air-pressure control valves and indicators to identify the location of the source, and connecting air hose and electrical wire. A source of 20 psig air and 110 volt electrical power are required for operation of the transfer system which can be easily moved and set up by one individual in 5 to 10 minutes. Tests have shown that rarely does a source become lodged in the transfer tubing, but two methods have been developed to handle incomplete transfers of the ^{252}Cf source. The first method consists of closing one air vent to allow a pressure impulse to propel the source to the opposite side. The second method applies to those ^{252}Cf capsules with a threaded or tapped end to which a small ferromagnetic piece can be attached; an incompletely transferred source in the transfer tube can then be guided to a position of safety by surrounding the transfer tubing containing the capsule with a horseshoe magnet attached to the end of a long pole.

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Acknowledgments

The authors appreciate the assistance of Treva Janzow of Frontier Technologies for making available personnel to evaluate the Portable Pneumatic Transfer System for Special Form ^{252}Cf. Their operation and evaluation was of benefit to us in determining whether this system warranted publication as an External Report.

A Pneumatic Transfer System for Special Form ^{252}Cf

1. INTRODUCTION

Special Form ^{252}Cf[a] is increasing in use for various analytical applications in industry. These sources are commonly used for prompt gamma neutron activation analysis, and for the analysis of transuranic materials. Many applications use relatively small sources of 5μg or less and can be safely handled manually within radiological safety practices resulting in insignificant exposure. However, for ^{252}Cf sources in the range of 10 μg to 150 μg that are handled frequently special precautions are recommended (e.g., the use of long poles, rapid infrequent transfers, and neutron shielding).

A pneumatic transfer system allows the user to activate the transfer of a ^{252}Cf source from a safe distance where the neutron and gamma radiation fields are at or near background levels. This transfer system is especially useful for developing a particular application for ^{252}Cf because it allows the experimenter to compare various experimental configurations without having to handle the ^{252}Cf source manually. It is for this latter reason that a pneumatic transfer system for Special Form ^{252}Cf was developed. This report describes the design and construction of the transfer system, lists radiation fields emanating from a modified 5-gal drum container holding a 16.28-μg source and reports on initial operating experience. Appendix A describes installation and operating instructions. Appendix B provides a list of parts and materials for construction of a pneumatic transfer system for series 100 Special Form ^{252}Cf.

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[a]Special Form ^{252}Cf series 100 sources consist of the source being doubly contained and weld-sealed in a stainless steel capsule with outside dimensions of 9.4-mm outside diameter and 38-mm length. These sources have been certified by the International Atomic Energy Agency (IAEA) to have passed extensive tests to demonstrate that they meet regulatory requirements for Special Form radioactive material as prescribed in the regulations of the IAEA and the U.S. Code of Federal Regulations Parts 100-199 for the transport of radioactive materials.

2. SOURCE CAPSULE

The pneumatic transfer system was intentionally designed for use with series 100 Special Form ^{252}Cf. Series 100 Special Form ^{252}Cf capsules are doubly encapsulated with welded seals and designed to hold californium masses ranging from below 1 μg to 10 mg. These capsules measure 9.4-mm (0.370 in.) OD by approximately 25-mm (0.984 in.) or 38-mm (1.496 in.) long and are made of 304L stainless steel or zircalloy-2. The ^{252}Cf source material is electroplated onto a fine wire that is located inside the inner capsule.

3. DESIGN OF PNEUMATIC TRANSFER SYSTEM

As larger and/or multiple ^{252}Cf sources for in-field measurements become necessary for improving quantitative elemental analysis of bulk material (e.g., 55-gal drums of mixed transuranic waste containing RCRA metals and halogens), better source handling methods are also needed. Specifically, a method to allow for frequent transfers of the source between its storage container and the irradiation position needed to be identified. The transfer system has to be versatile, dependable, easy to operate with low maintenance, and able to be set up in minutes. A pneumatic transfer system not requiring its own pressurized air reservoir tank is preferred. Further, radiation exposure has to be kept low and preferably unmeasurable during set up and use. A drum container that has been modified to serve as both a ^{252}Cf storage container as well as a certified Department of Transportation (DOT) shipping container could reduce the labor and hazard of transferring all Special Form ^{252}Cf sources.

3.1 Storage Container Station

To meet these objectives a storage container was designed so that, in principle, it could also be used as the shipping container. The air line and transfer tube connections at the storage container were all made with quick-release connectors to simplify set up and to reduce to negligible levels any radiation exposure to personnel performing this task. The electrical connectors are self-aligning, quarter turn type. The 3-inch diameter, cylindrical, delrin plastic fixture located near the center of the storage container, shown in Figure 1, provides the plumbing to safely transfer and receive the ^{252}Cf capsule. Construction of this piece from polyetheretherketone (PEEK)[a] plastic should be considered for ^{252}Cf sources >25 μg because it is easy to machine and is very durable and radiation-damage resistant. Plastic material was chosen for the fixture primarily because it moderates and captures many of the neutrons emitted from the source, and because, unlike many metals (e.g., aluminum), it is less likely to gall from multiple transfers of the capsule, and does not interfere with the operation of the proximity indicators. Proximity sensors were located at both the storage and irradiation stations and connected to LED lights on the control box to provide an indication of the source location. Electrically activated solenoid valves were used to control the movement of the capsule and to permit the closing of the vent valves at either the storage or irradiation stations when a capsule in transit stopped between them. All solenoid valves were selected and wired to default to an inherently safe position in the event of loss of electrical power.

Figure 2 is a detailed drawing of the cylindrical storage position fixture. The inlet air is connected to the lower 1/4" national pipe thread (NPT) tap in Section A-A to which the vent

[a]Polyetheretherketone (PEEK) is a high-temperature, crystalline thermoplastic resin suitable for high-performance injection moldings, wire coatings, and advanced composite structures. It offers an excellent combination of thermal and combustion characteristics, and it resists a wide range of solvents and proprietary fluids. PEEK resins are marketed by ICI Advanced Materials Group under Victrex tradename in unreinforced, 20 and 30 % glass-reinforced, and 30 % carbon-reinforced grades, depending on fiber orientation. Preliminary tests suggest that radiation resistance is extremely good with tightly coiled PEEK-coated wire samples withstanding 1,100 megarads without significant degradation.

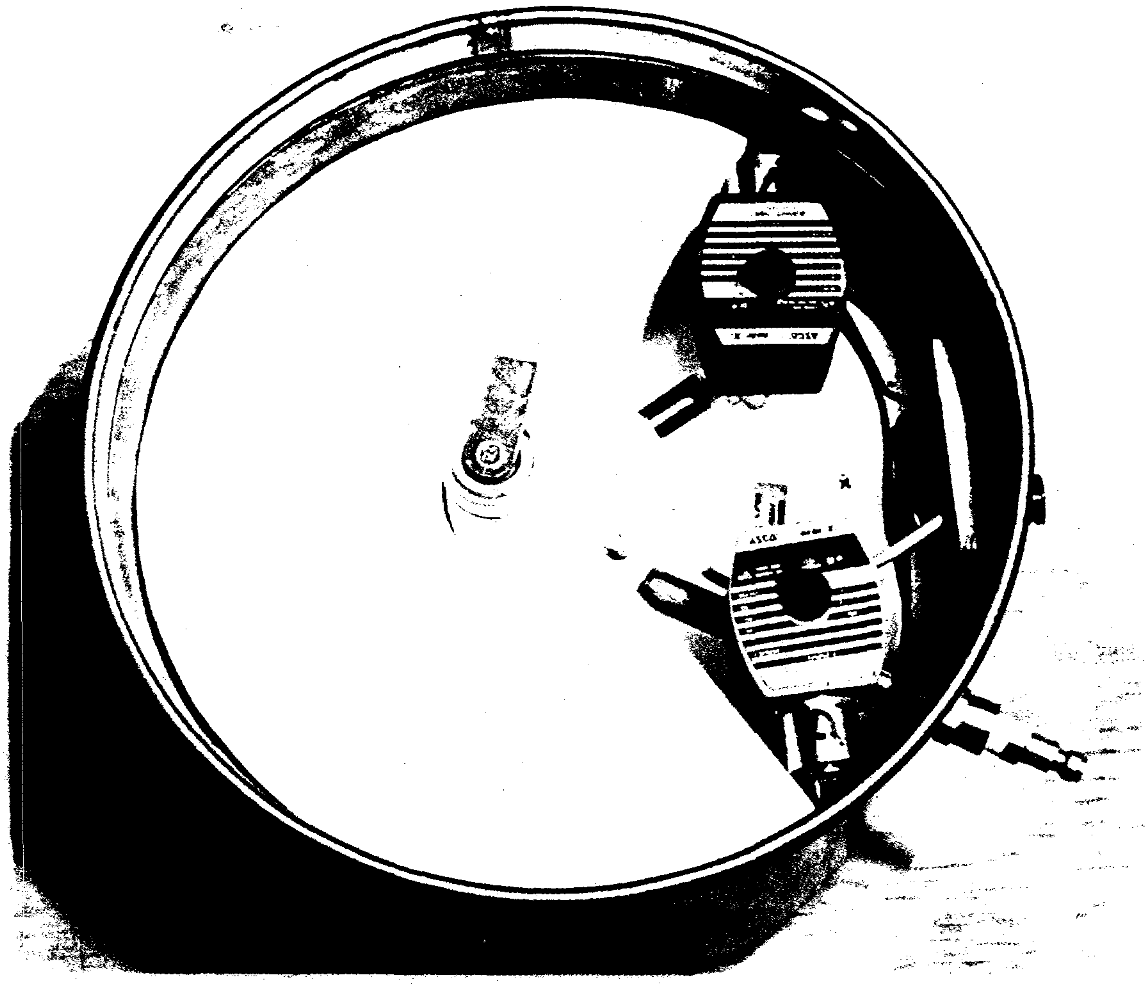


Figure 1. Top view of the ^{252}Cf storage drum showing the storage position fixture (i.e., cylindrical piece) in the center of the drum, quick-release connector at the top of the transfer tube (the plug insert is for shielding purpose and is removable by pulling it out by the aluminum tab), solenoid valves, and electrical connectors mounted on the side of the drum. The pipe protruding the drum is the air inlet line.

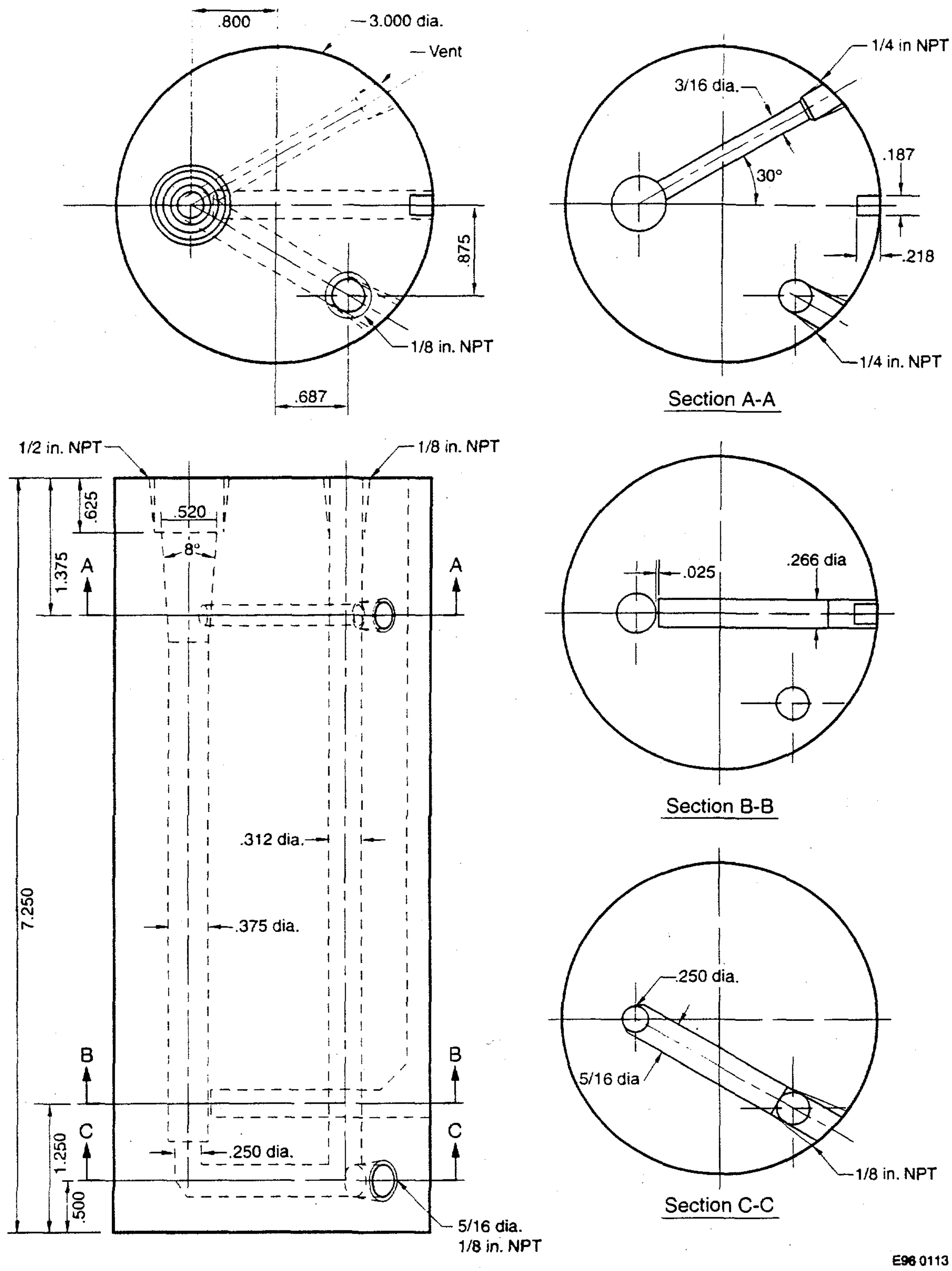


Figure 2. Detailed drawing of the storage position fixture, made of Delrin or PEEK plastic, with dimensions and cross section views at key positions.

valve is connected. The other end of this horizontal hole connects via a 3/16" diameter hole (see Section A-A) to a vertical hole of 0.312" diameter coming from the top of the fixture and extending to the bottom of the fixture where it intersects another horizontal hole of 5/16" diameter. Three separate machined holes were needed to achieve this inlet air path so two of the machined hole openings, the top horizontal (shown in Figure 1) and the bottom vertical surface holes, are sealed with brass plugs.

The transfer tube, ½" ID x 5/8" OD thin-walled polypropylene tubing, to transport the capsule is connected by a slightly modified Swagelok quick-release connector (inner diameter of fitting drilled out to prevent hold up of a capsule during transfer) to the ½" NPT tap and the proximity sensor is located at B-B with the electrical wires passing up along the notched outer wall of the assembly as shown in Figure 2 and attached to an electrical connector located on the outside of the drum (see Figure 1).

The air vent is located at the A-A horizontal position and is connected to the vent valve as shown in Figure 1. The vent solenoid valve is the one that does not extend to the outside surface of the storage container. The inlet air line connects to the fitting that extends to the outside surface of the storage container. If this drum is not placed in an overpack for shipping but is to be used as the shipping container, the electrical connectors to power the solenoid valves and the proximity indicator, and the inlet air line connector should be moved to a location inside the drum. For example, these connectors could be attached to a horizontal mounting plate surrounding the transfer tube. The diameter of the hole surrounding a seated capsule at B-B is only (0.005 ± 0.001)" larger than the outside diameter of the capsule. This allows an initial impulse of air to propel the capsule to the opposite station by momentarily opening the air inlet valve. The 8° taper at the top of the cylindrical storage position fixture allows for the centering and smooth arrival of a returning capsule transferred from the irradiation station. Finally, the inside bore of the Swagelok fittings are drilled out to remove any material on which a capsule could hang up. The storage position fixture can be installed into a carefully machined shield/moderating assembly consisting of polyethylene plastic as shown in Figure. 2, or a simplified version of the storage position fixture (see irradiation station source tube) can be secured within the drum and surrounded by a filling of water-extended polyethylene. A sheet of 0.5-mm thick cadmium surrounds the inside surfaces of the drum to reduce the thermal neutron field outside of the drum.

3.2 Irradiation Station

The source tube fixture, as shown in Figure 3, is the key part of the irradiation station and was made from PEEK. For ^{252}Cf sources >25 µg PEEK may be the fabrication material of choice at both stations based upon its radiation resistant properties and fatigue strength alone. As with the storage position fixture, the transfer tube connects to the top opening of the source tube fixture and the 8° taper allows for the centering and smooth arrival of the ^{252}Cf capsule. The vent valve is located about 1.5" below the top of the tube and is connected by the fitting as shown in Section B-B. The proximity indicator is located along the narrow portion of the tube with the indicator held in place by the poly neutron moderator/reflector block, shown in Figure 4, that fit

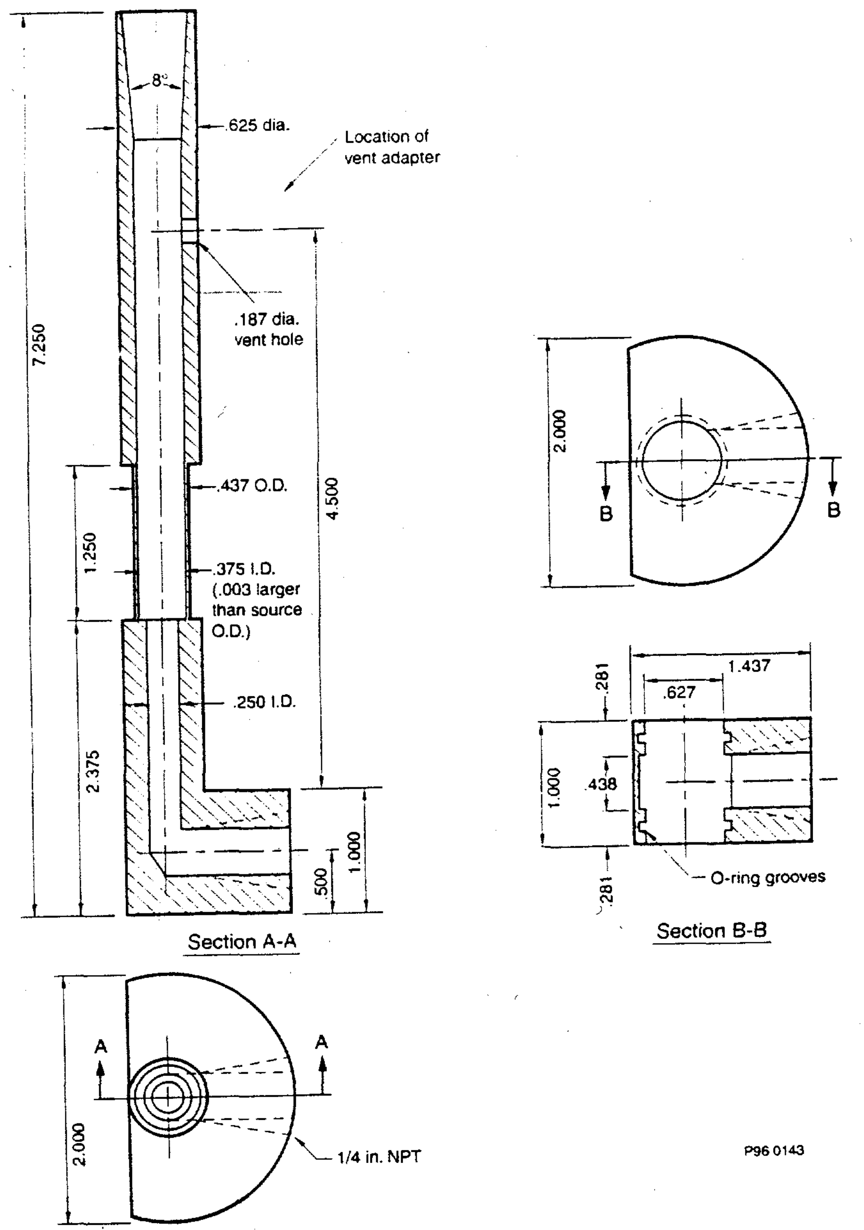


Figure 3. Detailed drawing of irradiation station source tube fixture through which the capsule travels upon arrival at or departing from the irradiation assembly. The source tube fixture slides into the moderating/reflector block with the vent adaptor sliding over the tube to surround the position of the vent hole in the source tube fixture. The vent hole is connected to the vent solenoid valve which is normally open and closed if a stuck capsule is to be freed by an air impulse from the irradiation end. The irradiation position is identified as the position along the source tube fixture where the wall thickness is thinnest.

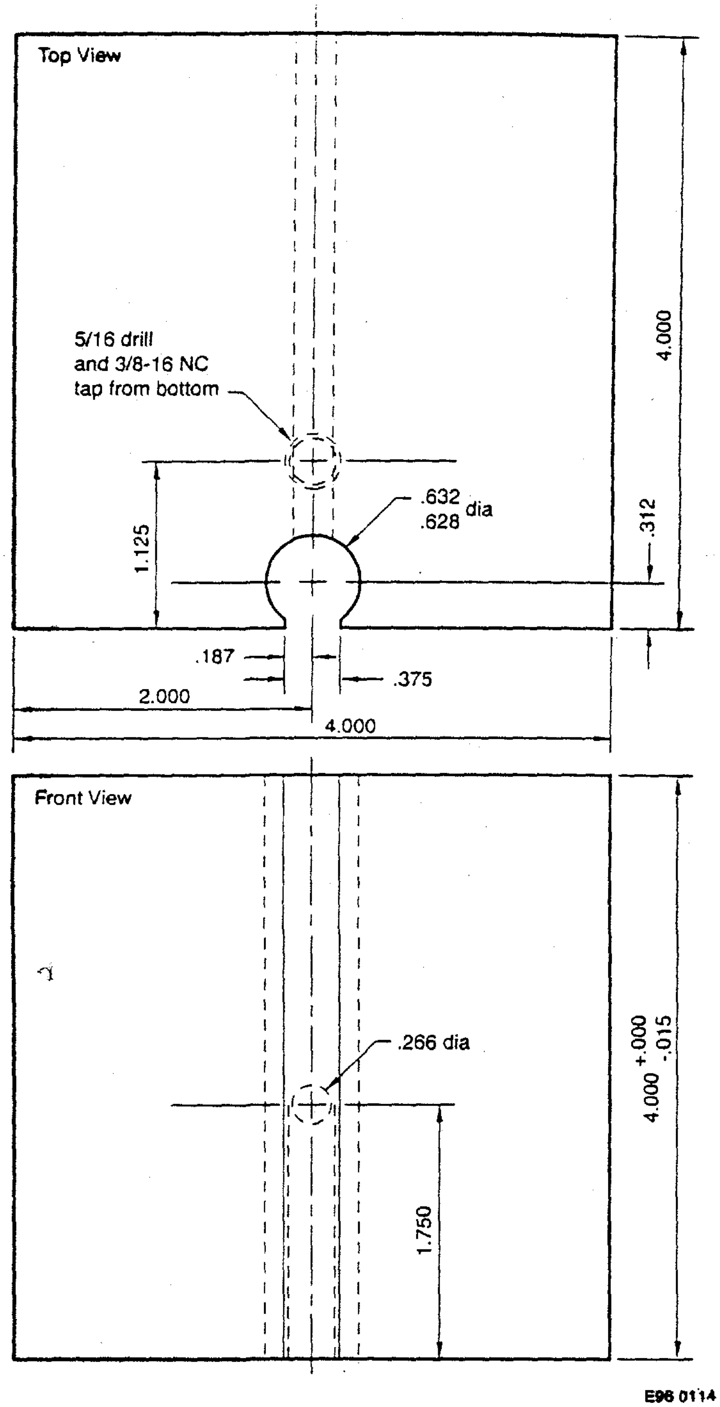


Figure 4. Drawing of the polyethylene moderator/reflector block showing larger circular slot hole at edge of the block through which the irradiation station source tube fixture slides, and smaller hole through which proximity indicator is positioned.

around the source tube shown in Figure 3. The narrow, thin-walled portion of the part in Figure 3 is where the ^{252}Cf source capsule is located during irradiations. This thin wall reduces the amount of moderation to the neutrons emitted in the forward direction from the source.

The purpose of the poly block in Figure 4, that surrounds the source tube fixture on three sides, is to enhance the number of thermal neutrons irradiating the sample located (but not shown) on the fourth open side. This block is positioned by sliding the poly block down over the source tube fixture. The vent adapter, equipped with "O" rings, then slides down over the source tube fixture and is positioned symmetrically around the 0.187" dia. vent hole. A second purpose for the poly block is to reduce the number of neutrons scattering into the surrounding laboratory by reflecting them back toward the sample. Various moderator/reflector blocks can be designed for one or multiple sources. The connectors for the transfer tubing, air supply, and vent lines and the associated solenoid valves are then installed as shown in Figures 5 and 6. Note that the irradiation station is supported and fastened to a wooden block with a 10" long Delrin plastic pipe serving to decouple the metal solenoid valves from the neutron field and avoid undesirable background from prompt γ rays caused by activation of the elements in the valve. Other means or support materials may be preferred depending upon the experiment. Since the source is initially located at the storage drum, quick release connections are not necessary at the irradiation station.

3.3 Control Box

The control box consists of switches to actuate the inlet air and air vent solenoids as shown in Figure 7. It also contains proximity LEDs to register the position of the ^{252}Cf source capsule, and the solenoid and proximity indicator circuitry as shown in Figure 8. If there is a loss of air pressure or electrical power the pneumatic transfer system defaults to a safe position (see solenoid valve default positions in parts list in Appendix B). A main power switch controls the 110 V ac power coming into the control box. This switch has a locking detent to prevent accidental on/off activation.

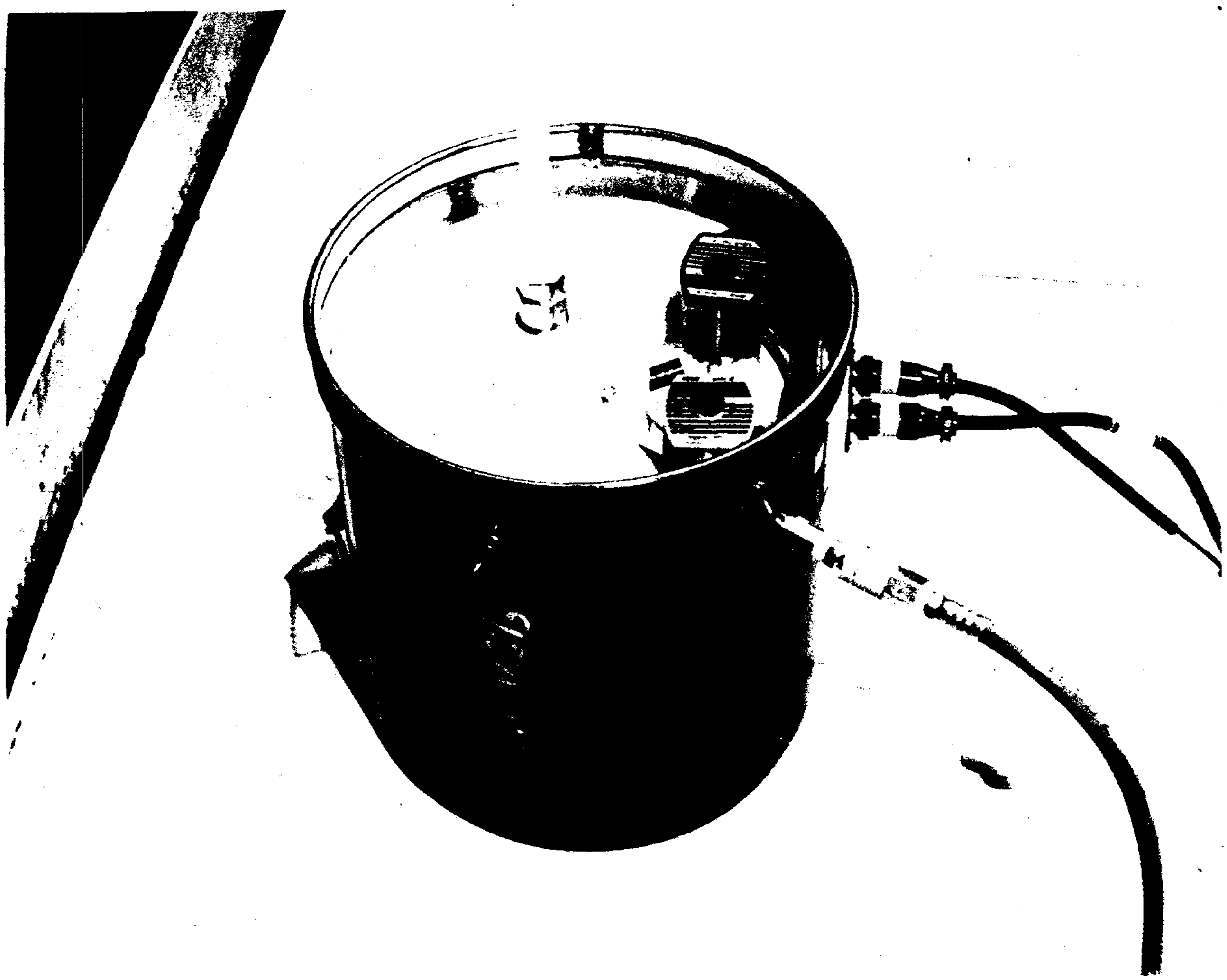


Figure 5. View of the ^{252}Cf storage drum with the transfer line, electrical connections, and air line attached.

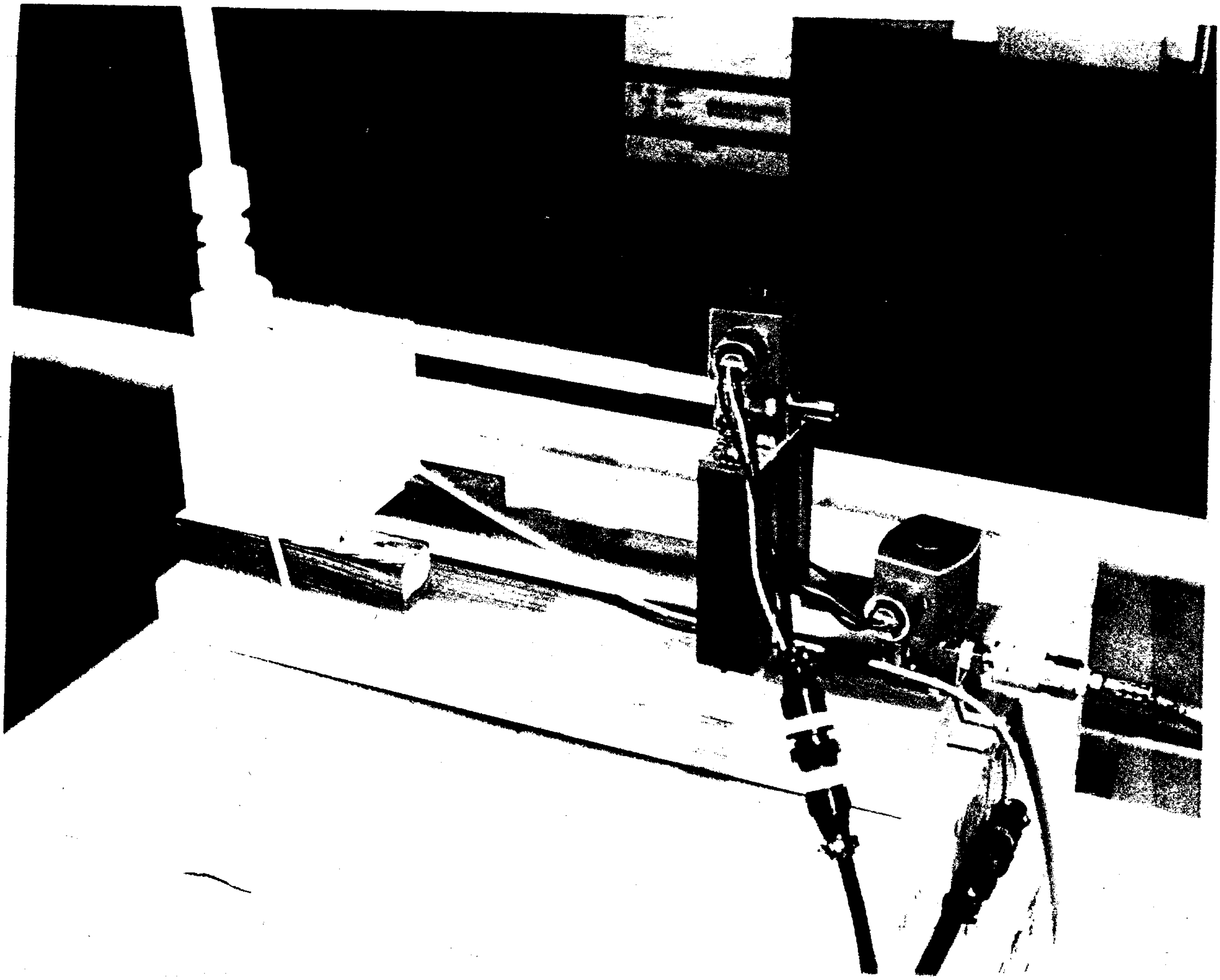


Figure 6. View of the irradiation station with the transfer line, electrical connections, and air line attached.

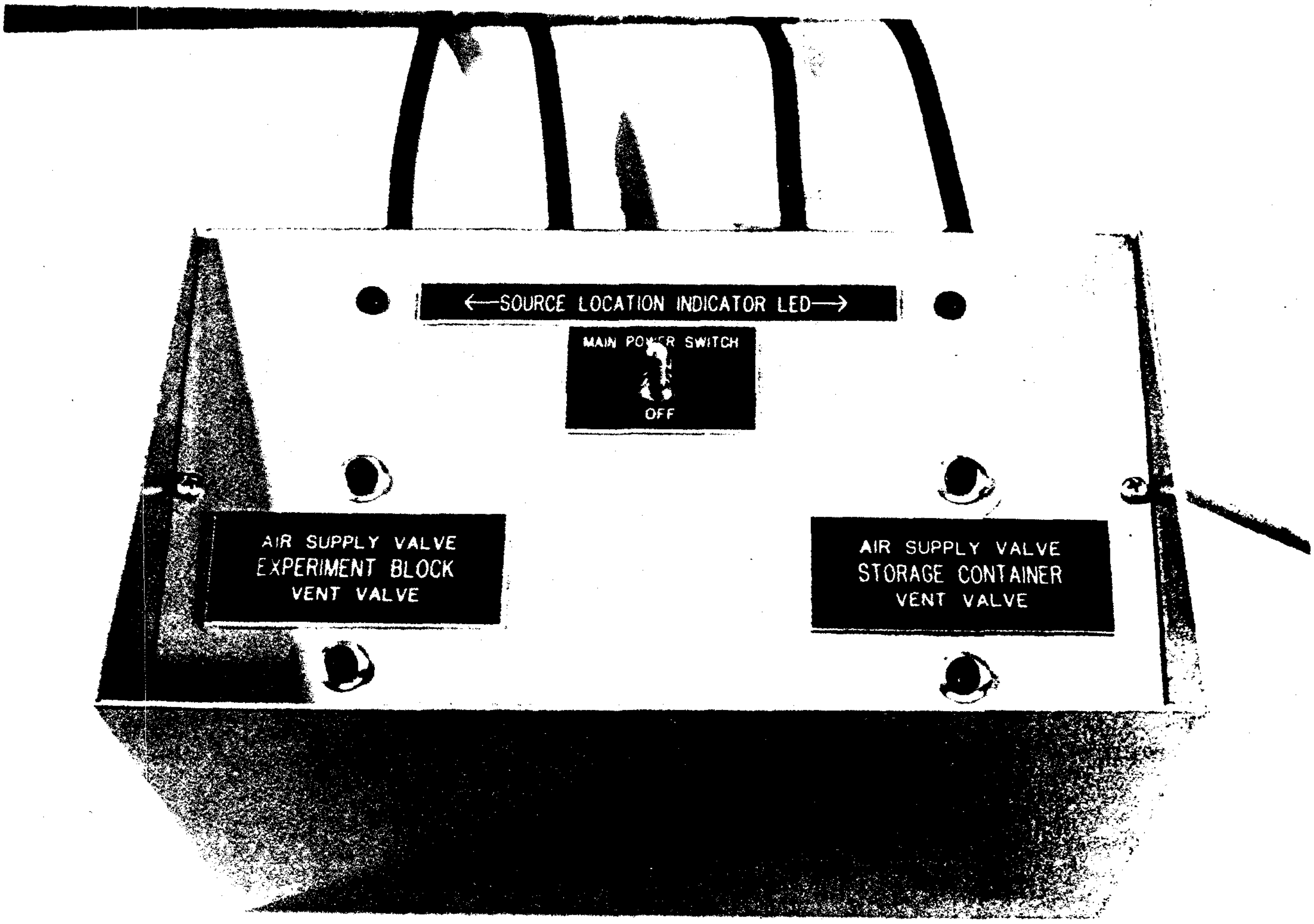
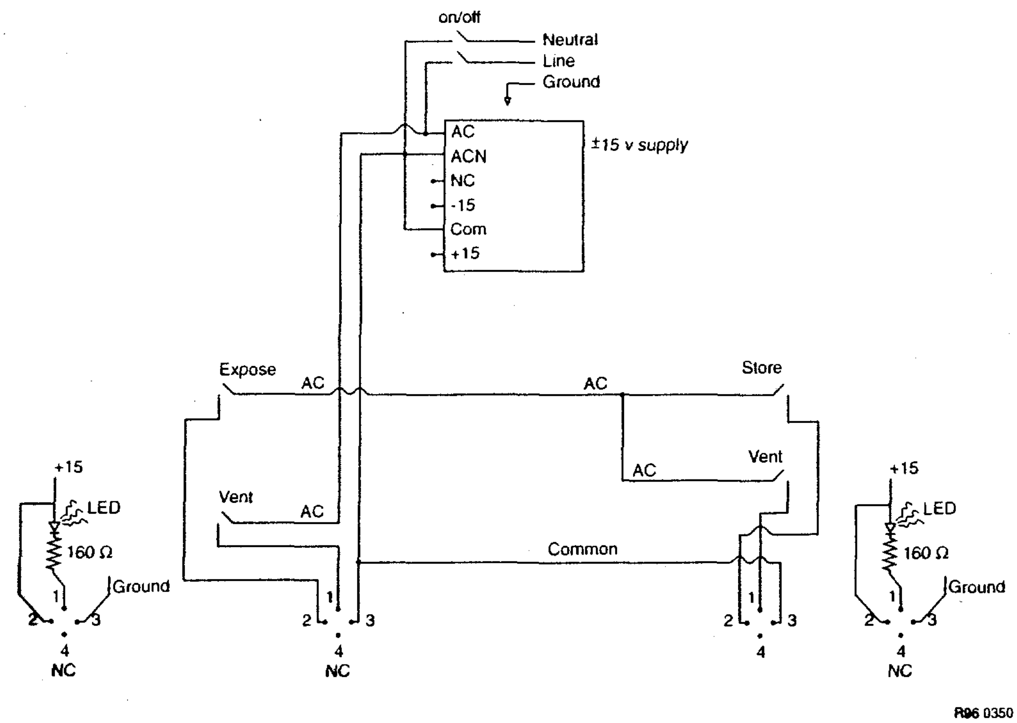


Figure 7. Control box with red indicator LED's at top of box, toggle switch with locking mechanism to prevent accidental activation or deactivation of electrical power, red momentary contact buttons for capsule transfer, black momentary contact buttons to close vent valves.



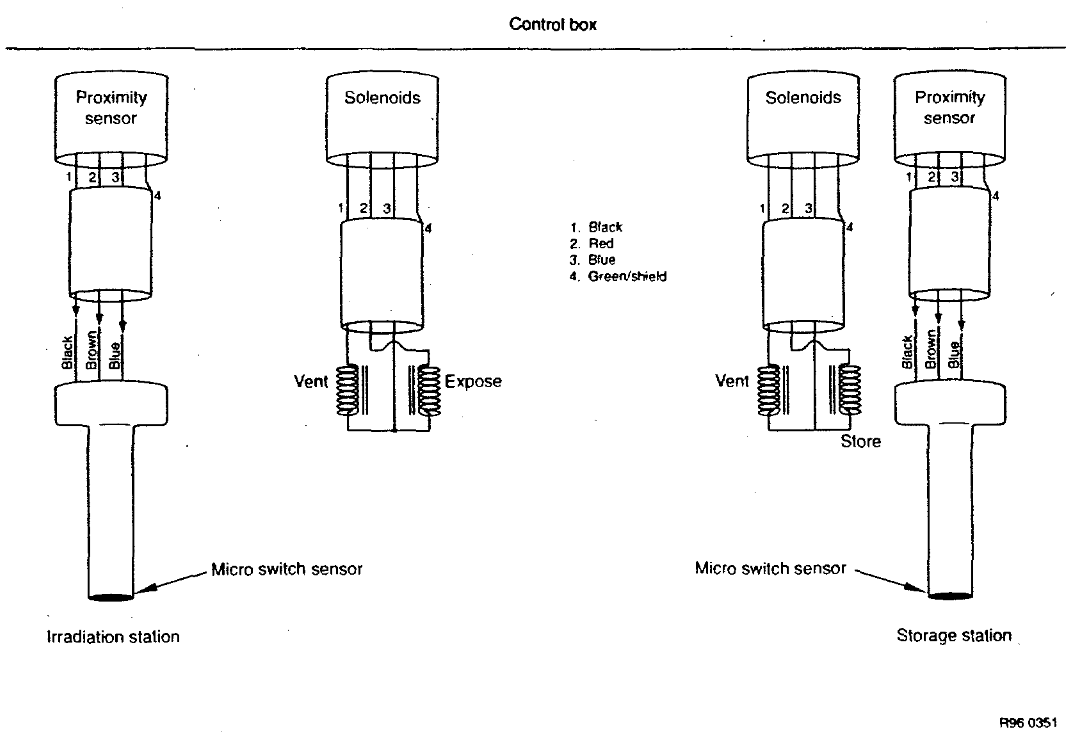


Figure 8. Electrical diagram for the solenoid valves and the proximity sensors and LED indicators.

4. RADIATION FIELDS

The radiation fields emitted from the storage container, as described in Section 3.1, were measured at the INEL with a 7.8 μg ^{252}Cf source loaded inside. The gamma and neutron fields are listed in Table 1 for the positions shown in Figure 9. The fields were measured with a PNR4 (serial # 801737) for neutrons and with a Bicron RSO50 for γ rays.

Table 1. Radiation fields at locations and distances indicated for the storage drum containing a 7.8 μg Special Form ^{252}Cf source.

View as shown in Figure 9	Distance from drum (feet)	Thermal Neutron Field (mR/h)	γ-Ray Field (mR/h)
A	contact	60	50
B	contact	25	25
C	contact	57	35
F	contact	29	28
E	contact	30	35
A	1.0	17	7
B	1.0	8	5
C	1.0	15	5
F	1.0	10	5
E	1.0	9	6
A	3.0	5	2
B	3.0	2	2
C	3.0	4	2
F	3.0	2	1
E	3.0	2	2

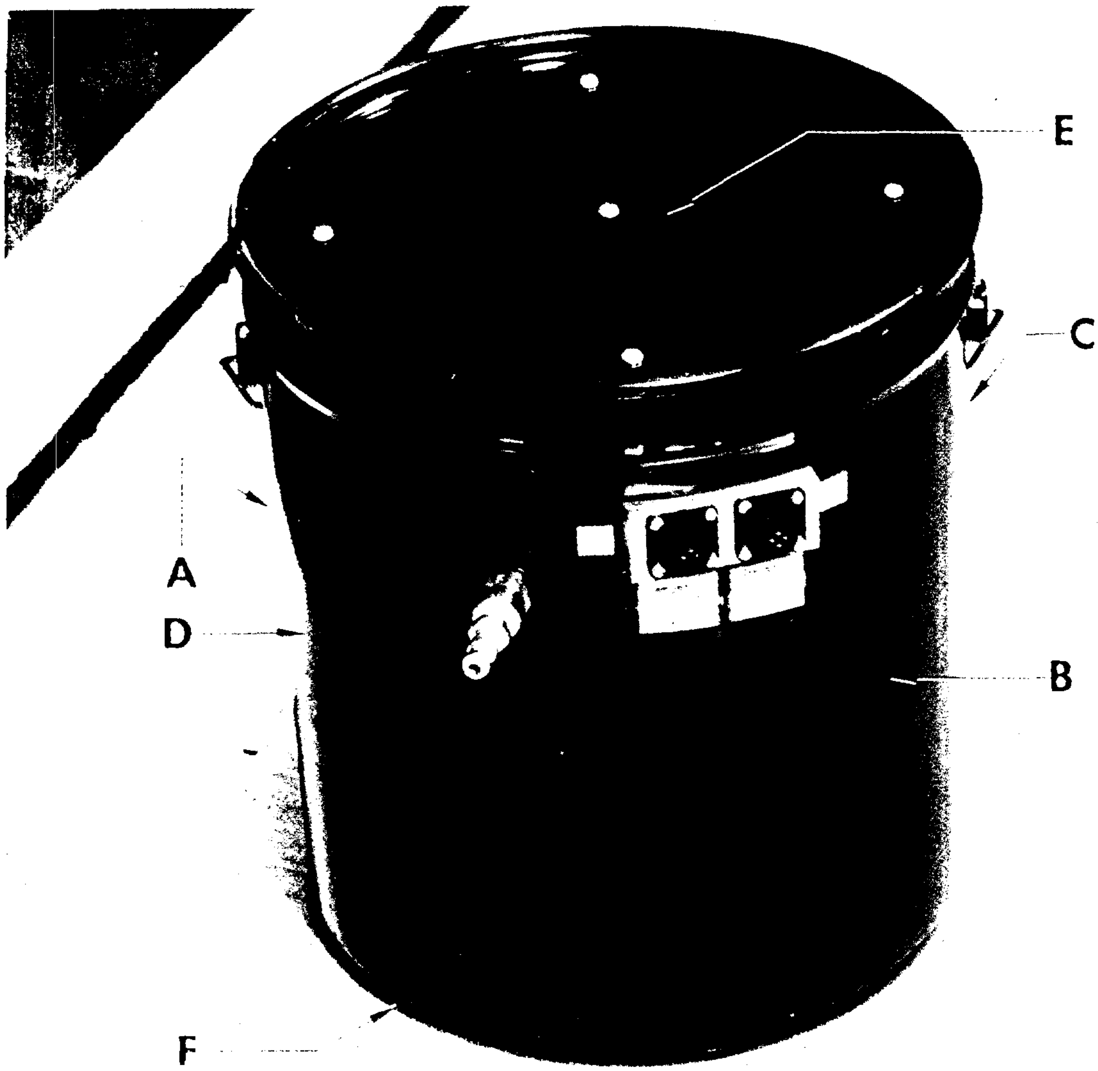


Figure 9. Diagram of the storage drum showing locations at which radiation measurements were made with a 7.8 μg ^{252}Cf source.

5. EXPERIENCE

Measurements with the pneumatic transfer system were performed at the INEL with a dummy capsule (no activity) followed by measurements at Frontier Technology Corp. with both dummy and actual ^{252}Cf-active capsules.

5.1 INEL Transfer Measurements

The INEL measurements were performed using the arrangement shown in Figure 10. The distance from the storage container to the irradiation station was approximately 20' with 15' being through the horizontal section of the transfer tubing. Repeated transfers performed flawlessly with no incomplete transfers occurring. In order to test the two methods for dealing with an incomplete transfer, an effort was made to cause an incomplete transfer with the capsule stopping in the horizontal section of the transfer tube. To accomplish this required a technique whereby the activating switch was only pressed for a split second. This was more difficult than was initially thought and each incomplete transfer required numerous attempts for success.

To move a capsule resulting from an incomplete transfer to a safe position at either station the vent valve at the opposite station was held shut at the same time its air inlet valve was activated. This prevented any of the inlet air from escaping out the vent valve. Usually, the capsule could be nudged to the station by repeating this sequence. (Since the capsule fits loosely in the transfer tubing air can flow around the capsule.) Sometimes, it was necessary to increase the air pressure from 20 to 30 psig. Under no conditions was it necessary to increase the air pressure above 30 psig. Higher pressures should be used only after reevaluating the system's ability to safely withstand and operate at higher pressures.

A second experiment was performed to demonstrate the second method for moving a capsule resulting from an incomplete transfer back to a safe position. In this method a strong horseshoe magnet was placed around the transfer tube where the capsule was located. The magnetic force drew the steel nut attached to the capsule toward the magnet which in turn was moved along the transfer line to the storage drum end until the transfer tube was nearly vertical. At this point the magnet was removed and the capsule dropped into the drum by gravitational force.

5.2 Frontier Technology Transfer Measurements

The tests performed at Frontier Technology were supervised by Toma Caldera and performed by Dwayne A. Carl and Brain C. Owens on the afternoon of May 15, 1996. The pneumatic transfer system was set up as instructed in the procedure that was sent with the instrumentation (see Appendix A). For the first test the storage container was set 17 ft. from the irradiation station with the storage container at a lower level than the irradiation station. The transfer line was raised to form a reasonably straight path for the capsule. The transfer tube was arranged so that the ends at the storage container and at the irradiation station extended vertically for ~2 ft. above the station before making a wide 90 ° arc for horizontal travel of the capsule.

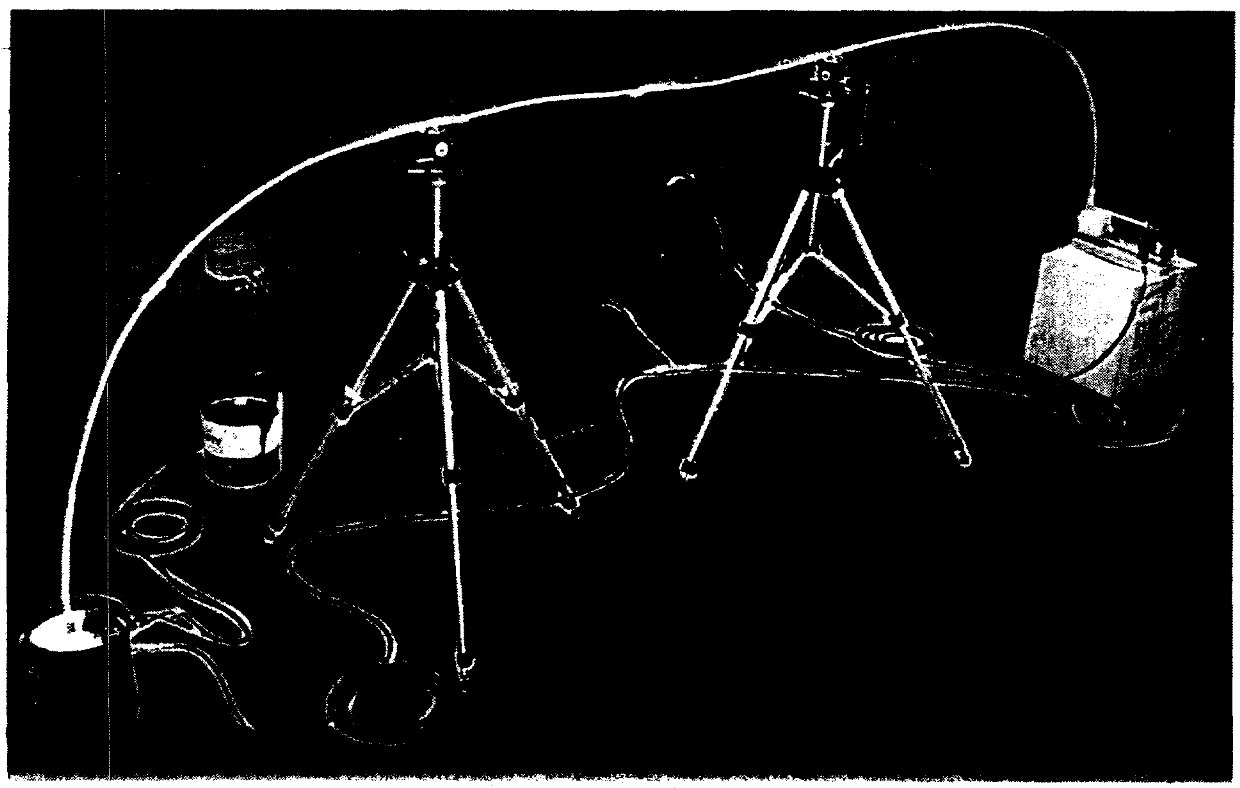


Figure 10. Layout of the pneumatic transfer system as set up at the INEL.

After the set up of the experiment, the dummy capsule was successfully transferred from the storage container to the irradiation station. This test was performed to check the functionality of the system before performing the test with a ^{252}Cf source.

The second test was performed to check radiation levels (in air, no shielding) at different points along the transfer system using the FTC-CF-252 Standard ^{252}Cf source with a content of 16.28 μg. The source was placed in the storage container and radiation levels were taken using a calibrated PNR4 neutron meter and a hand-held RO2 gamma meter (serial numbers 1004 and 287, respectively). The highest radiation level at the surface of the storage container are given in Table 2.

The next step was to transfer the source from the storage container to the irradiation station while monitoring the radiation level at the middle of the transfer tube with the PNR4 neutron meter and the RO2 gamma meter. This was done to monitor the movement of the source capsule to the irradiation station. The radiation level at the center of the transfer tube before the transfer measured 1 mR/h gamma and 3 mR/h neutron.

The ^{252}Cf source was then transferred to the irradiation station and the gamma and neutron meters noticeably deflected to higher readings and returned to the initial readings after seating of the ^{252}CF capsule in the irradiation station. The higher readings were not recorded due to the short time the field existed because of the fast transfer of the source capsule through the transfer tube.

The highest radiation levels measured at the surface of the irradiation station were 75 mR/h gamma and 800 mR/h neutron. The radiation levels from the irradiation station to the control box measured 0.2 mR/h gamma and 2 mR/h neutron (no shielding was in place).

Finally, the ^{252}Cf source was removed and replaced with the dummy capsule. This test was performed to check the functionality of the irradiation station when elevated above the storage station. The irradiation station was elevated to a height of 11 ft using a height-adjustable platform. The dummy source was transferred to the irradiation station. It was noted that the proximity indicator for the irradiation station did not light. This indicated that the dummy capsule did not properly seat, although it did transfer to the irradiation station housing. The incomplete transfer procedure was executed and the capsule did properly seat in the irradiation station.

The dummy capsule was transferred back to the storage container successfully. This test was repeated numerous times and again on a few occasions the dummy capsule did not seat properly. However, by using the incomplete transfer procedure the capsule was fully transferred as indicated by the proximity indicator. No disassembly of the system was required to seat the capsule. This test indicates the need for higher inlet pressures if vertical transfers are required.

Table 2. Highest radiation level at surface of storage drum containing a 16.28 μg Special Form ^{252}Cf source.

Distance from drum (feet)	**Thermal Neutron Field (mR/h)**	**γ-Ray Field (mR/h)**
contact	140	100
one meter	8	2.2

Before concluding this last test, the dummy capsule was intentionally stopped between the storage container and the irradiation station. To do this the irradiation station was lowered to a 4 ft level and a dip was created in the transfer tube (no damage was done to the transfer tube in this procedure). The dummy capsule stopped at the location of the dip during transfer. Following the incomplete transfer procedure, the transfer was completed successfully without disassembly of the system. In none of the incomplete transfers was it necessary to pull the capsule back to a position of safety with a magnet.

6. SUMMARY

A pneumatic transfer system has been developed for use with series 100 Special Form ^{252}Cf to reduce the exposure to personnel handling sources of ^{252}Cf with masses up to 150 μg by permitting remotely activated two-way transfer between the storage container and the irradiation position. The pneumatic transfer system also permits transfers for reproducible repetitive irradiation periods. A source of 20 psig air and 110 volt electrical power is required for operation of the transfer system which can be easily moved and set up by one individual in 5 to 10 minutes. Tests have shown that rarely does a source become lodged in the transfer tubing, and two methods to handle incomplete transfers of the ^{252}Cf source have been tested to successfully move an incompletely transferred source to a position of safety. Initial performance tests indicate that the pneumatic transfer system performs as designed, but that experience and use are necessary to identify any deficiencies in materials or design that may become apparent with extended use. The air supply source can typically be plant air at 90 to 100 psig, since the pressure regulator has the capacity to reduce the pressure to the 20 psig requirement.

APPENDIX A

^{252}Cf Pneumatic Transfer System

Operating Instructions[a]

1. COMPONENTS

The ^{252}Cf Pneumatic Transfer System consists of three assemblies: a) the storage container (5-gal drum) that stores the Special Form ^{252}Cf source when it is not in use (Figure 1 of text), b) the irradiation station (polyethylene cube with plastic pipes to which solenoid valves are attached) to which the source is transferred for experimental work or for irradiation of a sample (Figure 3 of text), and c) the control station (Figure 7 of text) which consists of a sheet metal box containing four control buttons (switches) for operation of the solenoid valves, a main power switch, and proximity switch light indicators. The solenoid valves are controlled electrically. Two of the switches allow compressed air to be injected from below the capsule to propel it to the other station. The other two switches permit closing of the appropriate vent valve when the capsule is stuck between stations so that the full force of an air impulse can be directed toward the stuck capsule to push it to the other station. The proximity switch indicators light when the capsule is fully seated. Due to the close tolerances between the outside diameter of the capsule and the inside diameter of the machined portion of the transfer tube comprising each station, it takes several seconds for the capsule upon arrival at a station to become fully seated. This is due to the air cushion formed by the volume of air below the vent that takes several seconds to escape around the arriving capsule.

2. INSTALLATION

2.1 Packaging

The entire system can be shipped inside a 4-ft x 4-ft x 2-ft high foam-lined shipping box. The 5-gal storage container is located between sheets of foam to prevent it from shifting during transportation. The irradiation assembly is located adjacent to the shipping container with the wooden base facing the storage container to minimize potential damage to its more delicate parts. The control box and coiled tubing are located around the inside outer perimeter of the shipping box being careful not to crimp any of the transfer line, or air line. Also coiled inside are the electrical cables with there connectors.

[a]See disclaimer at end of Appendix A.

2.2 Assembly

1. Gather all components and connecting hardware and check that nothing is visibly damaged.

2. Remove the locking ring and lid of the 5-gal drum (source storage container). The drum has a plastic plug to cover and contain the ^{252}Cf capsule on all sides and prevent the streaming of neutrons from the drum during storage and shipment. Remove the plug by its aluminum tab and keep it with the lid so it doesn't get lost. It is recommended that all pneumatic transfer systems be checked and demonstrated to be free of defaults with a surrogate capsule of identical dimensions to the ^{252}Cf capsule prior to use with an actual source.

3. Place the irradiation station at a distance of ~15 to 20 ft. from the storage container.

4. Place the control box at a safe distance from both the storage drum and the irradiation assembly. The control station should be located at sufficient distance from the storage drum and the irradiation assembly for personnel to be safe from any emitted radiation fields.

5. Connect the capsule transfer line at the drum and irradiation assembly. This is the stiff plastic tube that transfers the capsule.

   Warning. Avoid causing any kinks in the plastic transfer line. Kinks in the tubing mean that the tubing must be replaced! All bends in the tubing should have at least a 2 ft radius to avoid having the capsule get stuck due to too sharp of a bend.

   The transfer line should be connected with the quick release connector end at the storage container and the manual connector at the irradiation station.

   Warning. The transfer line should be connected prior to the air line to avoid blowing the capsule at high speed into the room or worse into the face of the operator.

6. Connect the air lines. These are the lines that carry air from plant/instrument air, compressor, or air cylinder to the storage container and to the irradiation station. These are all quick release fittings for convenience. There is a "T" connection in the line to feed both the drum and the irradiation assembly from one source of pressurized air.

   Warning: Do not attach the feed end of the air line to the plant air prior to connecting the electrical power to the solenoid valves and to the control box.

7. Connect the electrical wires from the control box to the solenoid connections at the

storage container and irradiation station. The connectors should be color coded to avoid erroneous connections. It is recommended that the electrical lines be strung out so that they can be visually traced from the control box to each capsule position (i.e., drum end and irradiation station end).

8. Check that all couplings at each connector are secure and fully seated. A partially coupled air fitting can blow apart at the most inopportune time.

9. Connect the electrical power of the control box to 110 v ac power.

Warning. Be sure that a manual air valve near the air inlet allows bleeding of the air line after the feed air is shut off.

10. Connect the feed side of the airline to a regulated supply with the air pressure adjusted from 0 psig to 20 psig via the regulator. This is sufficient pressure for the transfer line length of 15 to 20 ft with both stations at the same height. Be sure to use compatible fittings on both ends at the feed line connection to avoid pressure hazards or leaks. If an air cylinder is used, it should have two regulators to prevent the possibility of 2000 psig from being placed on the air line should one regulator fail.

If the capsule gets stuck in the transfer line during transit, an additional 5 or 10 pounds of pressure may help to dislodge it but under no circumstances should more pressure be applied to the line above the pressure ratings of the solenoids and connectors.

2.3 Operation of Pneumatic Transfer System

11. Check that the proximity sensor on the storage container end is operating by checking that its associated red light is on. If the light is not on, go to the troubleshooting portion of this procedure below. Note, the proximity sensor can only be lit if there is a capsule present.

12. To transfer the capsule from the storage container to the irradiation station, press momentarily (only for a second) the top button switch associated with the drum solenoid feed supply. (The top button switch should be red in color. It controls the air to the capsule. The bottom button switch should be black and controls the vent solenoid).

The capsule should have transferred within a couple seconds to the irradiation station. It will take about three or four seconds for the capsule to become fully seated and for the proximity indicator to light. Check that it lights.

13. To send the capsule back to the storage container drum, press momentarily (only for a second) the top button switch associated with the irradiation station.

2.4 Stuck Capsule Procedure

It is difficult to intentionally stick a capsule. However, with some practice it is possible to press the transfer button for such a brief time (split second) as to release only enough air to cause the capsule to stop between stations. When this occurs, it is necessary to close the vent line on the side where additional air is to be blown so that it cannot by-pass the transfer line by passing out the vent. This is done by pressing both the vent and the supply buttons simultaneously. Movement of the capsule can be observed through the translucent transfer line. If the capsule only moves a short distance, it may take a series of these moves to drive the capsule the entire distance to a position of safety. Once the capsule is above the destination station, it should slide by gravity into the storage drum or irradiation assembly.

If the capsule does not move, it may be necessary to increase the pressure to 25 or 30 psig and repeat the above steps. If this does not work, **do not increase the pressure further.** Rather, turn off the feed air, bleed the pressure line, and use the horseshoe magnet to surround the capsule and pull it to the drum position. Note: some Special Form ^{252}Cf sources are not constructed to permit the attachment of ferromagnetic material to one end of the capsule.

2.5 Disassembly

Disassembly should be performed in the reverse order of the assembly (see Section 2.2) instructions.

Warning. Bleed the pressure for the air line after shutting off the air supply but before disconnecting any fittings/connectors.

2.6 Troubleshooting

1. If either proximity sensor light is not working or the capsule seems stuck, disconnect the 110 power, turn off the air line pressure and disconnect the air line from its source of pressurized air, and bleed the air line completely.

2. Once all energy (air pressure and electrical) is removed from the system, disconnect the transfer line from both ends, being careful not to place any part of the body over the hole potentially containing the capsule. Briefly examine for the presence of the capsule. If the capsule is present, it may not be fully seated or the indicator light or proximity sensor is faulty. Remove the capsule, if present, and examine the source tube or storage position fixture for any burrs or other obstructions that could prevent the capsule from being fully seated. Do not modify the tolerances by machining either the capsule or the tubing.

Disclaimer:

These instructions were prepared to provide guidance in the assembly, operation, and disassembly of the ^{252}Cf pneumatic transfer system. Neither the United States Government, nor any agencies thereof, nor any of their employees, makes any warranty, expressed or implied or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

APPENDIX B

Materials and Supplies

The following is a list of the key materials and parts used to construct the pneumatic transfer system. This is not intended to be an exhaustive list.

Materials:

1' x 4" x 4" long polyethylene plastic bar stock

4' x 4' x 1" thick polyethylene plastic sheet stock, or

4' x 4' x 2" thick polyethylene plastic sheet stock

1' long x 2" diameter polyetheretherketone (PEEK) plastic rod stock

2' long x 1/4" diameter Delrin plastic pipe (may have to be made) stock.

1' x 3' x 0.02" thick cadmium sheet (if used to line the inside of the drum).

Parts:

Storage Container Station

Item	Number	Part Description
1	1	5-gal steel drum with lid and ring.
2	1	ASCO solenoid valve with female 1/4" NPT (2-way normally open) - 1/4" x 1 ½" nipple, 1/4" coupling, 1/4" male, part No. 8262G265.
3	1	ASCO solenoid valve with female 1/4" NPT (2-way normally closed) - 1/4" x 1 ½" nipple, 1/4" coupling, 1/4" male, part No. 8262G212.
4	2	1/4" NPT x 2" to 3" pipe nipple.
5	1	Quick-release Swagelok fitting for 5/8" transfer line connected to ½" NPT, part No. QF8-BW (female) and QF8-S (male).
6	1	Proximity indicator, 15 volt power, Honeywell part No. 982FS1-A3N-6.5-L.
7	2	female 1/4" NPT to quick release male air inlet connector
8	2	1/8" NPT brass plugs
9	1	5/8" plastic connector
10	2	Electrical connectors for electrical power to solenoid valves and proximity indicator

Irradiation Station

Item	Number	Part Description
1	1	ASCO solenoid valve with female 1/4" NPT (2-way normally open) - 1/4" x 1 ½" nipple, 1/4" coupling, 1/4" male, part No. 8262G265.
2	1	ASCO solenoid valve with fewmale 1/4" NPT (2-way normally closed) - 1/4" x 1 ½" nipple, 1/4" coupling, 1/4" male, part No. 8262G212.
3	2	1/4" NPT x 10" to 12" plastic pipe
4	1	Quick-release Swagelok fitting for 5/8" transfer tube connected to ½" NPT
5	1	Proximity indicator, 15 volt power
6	2	female 1/4" NPT to quick release male air inlet connector
7	2	y" diameter x z" thick "O" rings to fit source tube (see Section B-B of Fig. 3)

Control Box and Connecting Pieces

Item	Number	Part Description
1	1	Electronic box
2	2	Red button 110 volt momentary switch electrical switch
3	2	Black button 110 volt momentary electrical switch
4	1	Electrical 110 volt toggle main power switch with lock to prevent accidental activation
5	1	15 volt power supply
6	1	100' of ½" ID x 5/8" OD polypropylene plastic tubing
7	1	100' of 1/4" air supply hose
8	1	"Tee" connector for air line hose with air line fittings
9	1	Air-line regulator, 1/4" NPT AMFLO part No. 2UOA.
10	1	100' of No. 14 three-conductor electrical wire
11	1	Air line filter, 1/4" NPT AMFLO 2010A
12	1	Air-line pressure gauge, 0 to 160 psig.
13	1	Isolation ball valve for air pressure shut off.
14	1	100 ft of Belden 8425 5-conductor w/shield.
15	10	Amp electrical connector, part No. 206062-3
16	10	Amp electrical connector, part No. 200821-1
17	2	Amp electrical connector, part No. 206430-2
18	8	Amp electrical connector, part No. 206429-1
19	1	Union, straight 5/8", part No. 3-008-003-04-01