285
6-15-65 MASTER

LOS ALAMOS SCIENTIFIC LABORATORY
LOS ALAMOS [REDACTED] of the [REDACTED] NEW MEXICO
University of California

POSSIBLE REMOTE MAINTENANCE
AND REPAIRS ON REACTORS AT NRDS

PATENT CLEARANCE OBTAINED. RELEASE TO
THE PUBLIC IS APPROVED. PROCEDURES
ARE ON FILE IN THE RECEIVING SECTION.

UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express 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. Reference 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.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

All LA . . . MS reports are informal documents, usually prepared for a special purpose and primarily prepared for use within the Laboratory rather than for general distribution. This report has not been edited, reviewed, or verified for accuracy. All LA . . . MS reports express the views of the authors as of the time they were written and do not necessarily reflect the opinions of the Los Alamos Scientific Laboratory or the final opinion of the authors on the subject.

Printed in USA. Price \$1.00 Available from the
Clearinghouse for Federal Scientific and Technical Information,
National Bureau of Standards, U. S. Department of Commerce,
Springfield, Virginia

LA-3242-MS
UC-80, REACTOR
TECHNOLOGY
TID-4500 (39th Ed.)

LOS ALAMOS SCIENTIFIC LABORATORY
LOS ALAMOS ████████ of the ████████ NEW MEXICO
University of California

Report written: November 1964

Report distributed: May 1965

**POSSIBLE REMOTE MAINTENANCE
AND REPAIRS ON REACTORS AT NRDS**

by

W. Charles Wofford

ABSTRACT

Component malfunctions and failures on Kiwi series reactors at NRDS cannot presently be repaired or replaced remotely after reactor start up at the test cells. This report discusses possible methods to correct such malfunctions on some components which might alter or abort a reactor test. The use of shielded vehicles for repairs or observations is discussed briefly, and past incidents of component failure and hydrogen leaks are mentioned. Redesign of certain existing reactor/test car components would be required, and the state of the art in remote handling would have to be expanded. A stockpile of spare reactor/test car components would be required for a reactor maintenance program.

ACKNOWLEDGEMENT

Acknowledgement is given Don Grisham, J-9, NRDS, for an earlier memo entitled "Emergency Repairs to Kiwi Reactors."

INTRODUCTION

Detailed disassembly operations using standard and special remote handling fixtures and manipulators are performed almost routinely on radioactive Kiwi reactors at the R-MAD Building at NRDS. Since 1959 we have had a total of nine hot reactors to disassemble. Disassembly operations on the past two Kiwi reactor tests, the B4D-202 and the B4E-301, conducted in May and August 1964, were carried out very successfully. These two disassemblies utilized some newly designed remote handling equipment to speed up the disassembly and to aid in post mortem examinations of the fuel elements and other components. We do anticipate new disassembly problems with each reactor, however, and an example would be an aborted reactor test.

Even though a constant effort to improve the reactor test car and reactor hardware continues, it is possible that a malfunction or failure will sometime abort a reactor test. The present reactor/test car design, the reactor test philosophy, and the existing remote handling equipment at NRDS do not permit remote maintenance, repairs, or replacement of components on the reactors. The present philosophy, for example, in the event of a hydrogen leak, or reactor/test car component failure during a reactor test, is to modify the Test Experimental Plan.

It is the purpose of this report to discuss malfunctions or failures that are not presently considered repairable remotely and to present possible methods of remote repair or replacement of malfunctioning components. Such remote operations and replacement of components on reactors have never been performed at the R-MAD Building. An example of an emergency condition that occurred in the past is also discussed.

DISCUSSION

Consider, for example, that a hydrogen leak develops in some portion of the test car piping, in the reactor nozzle, or in some other reactor or test car component during the initial stages of a test (see Figure 1). The Test Experimental Plan would have to be modified by perhaps decreasing the reactor run time, reducing its power level, or even halting the test. Any restarts would be unlikely. Obviously, it would be very expensive to alter or discard this several million dollar test. It would be advantageous to repair the reactor/test car malfunctions or replace components remotely. But this would require a stockpile of spare components, and at the present time we have few spare components on hand. A nozzle, for example, costs several hundred thousand dollars; and, obviously, this approach would be expensive.

Consequently, much study must be given to a reactor remote maintenance program. Which components

would be deemed repairable or replaceable remotely? How much new reactor design would be necessary for remote maintenance operations? Would we sacrifice the data lost on an aborted test for the time required for maintenance, the expense for spare components, etc.?

If such a program were set forth, such maintenance could be performed at the test cell on the unshielded test cell pad, or in the shielded lower disassembly bay of the R-MAD Building. No remote handling equipment is available, however, at the test cell pad.

Pinpointing the location of a malfunction on the reactor/test car is a big problem due to the limited capabilities in viewing the reactor close-up. Run time, power level, and time after reactor shutdown of aborted tests will, of course, vary the amount of radioactivity present. Presently, there are two TV cameras at Test Cell "C" mounted on permanent concrete supports to monitor the reactor/test car from about 200 feet. Pan and tilt controls and zoom lens are, of course, remotely operated from the Control Point (CP). Additional tripod mounted TV cameras are sometimes brought in to this radius for additional coverage. Present mirror system photographic coverage at Test Cell "C" is limited to two photo bunkers located some 700 and 830 feet from the reactor/test car. These TV and photographic cameras have limited locations which are too distant for detailed close-up viewing, and lack the resolution needed to locate and examine a malfunction. High resolution radiation-resistant TV cameras are not considered here because of the long 1-1/2 miles of control cable to the Control Point.

After each of the previous two tests a Questar telescope was set up for general over-all observation a few hundred feet from the reactor/test car. However, personnel using the telescope were limited to a few minutes of exposure time, and also only portions of the test car could be seen.

Due to these viewing limitations a shielded vehicle could be useful for a preliminary malfunction inspection. and three shielded mobile manned vehicles are now available at the test site: the Beetle, the Bat, and the Masher. Very briefly, the Beetle is a modified track-laying vehicle equipped with two General Mills Model 550 manipulators. Its one man shielded cab can be rotated 360 degrees and hydraulically elevated 15 feet. The Masher is a two man modified version of a T-51 tank recovery vehicle equipped with a bulldozer blade and a 30-ton-capacity crane. The Bat is a four-wheeled, pneumatic-tired, one man shielded tow tractor. It appears that all remote maintenance operations would best be performed in the lower disassembly bay rather than attempted with these or other shielded vehicles on the test cell pad. The above vehicles, however, could be used separately or together for general close-in observation and malfunction inspection of the reactor test car.

KIWI-B

Figure 1. Kiwi Reactor/Test Car

These vehicles have never been used to view or to perform any remote operations on a Kiwi reactor.

Such vehicles could accommodate portable radiation-resistant TV cameras and periscope-cameras within a 100-foot radius of the reactor/test car. These operations would again depend on the level of radioactivity. A TV video tape recorder mounted inside the vehicle would provide monitoring inside the vehicle, or a reel for the TV camera control cables to existing terminal boxes would provide recorded monitoring.

REACTOR/TEST CAR REPAIRS

Four categories of different modes of reactor/test car malfunctions are as follows.

Category I

This category consists of the repairs that can be made manually in the shielded test cell flow control room, known as the FCR, or remotely on the test pad in the partially shielded privy which supports the reactor on the test car (see Figure 1). Some of the items located on the test car plug which could be repaired or replaced in the FCR are:

1. Rod control servo-valves and associated wiring.
2. Rod control pneumatic lock pin control valves and associated wiring.
3. All test car to test cell piping hookups which include all the piping in the plug, consisting of the 8-inch propellant line, 4-inch water line in, 4-inch water line out, 6-inch purge line, 6-inch emergency purge line, and 3-inch vent chilldown line.

There appear to be few maintenance problems, regardless of run duration, which have to be done remotely once the test car plug is mated into the test cell face and thus shielded from the reactor. Manual disconnection of a hot reactor/test car in the FCR for transportation to the R-MAD Building and reconnection in the FCR can be accomplished now.

Repairs of items manually or remotely in the privy at the test pad might be accomplished if the reactor test aborted in its early stages. In this case, disconnection of the test car from the test cell would be unnecessary. The items that might be repaired or replaced are:

1. Pressure probe transducers and associated piping and wiring.
2. Rod control actuator assemblies and associated piping and wiring. This wiring is single lead wire, and it is unlikely that it would need replacing unless a serious accident occurred. In this event, it is probable that serious damage would

have also resulted to the other systems. The actuator assemblies could be replaced only after a short run duration, because it seems impractical to redesign for a remote complete replacement capability. The replacement of an actuator assembly could be made using present hardware. A new actuator and an actuator lift fixture could be brought into the privy and placed under the faulty actuator. The electric connector and the hydraulic and pneumatic lines would have to be disconnected. Six nuts from the 1/2-inch retaining bolts on the roof would have to be removed, and the actuator then lowered and removed. The new actuator must be raised, engaged with the control rod shaft, and rotated against the control rod zero stop. It is then resealed and the six nuts replaced. These operations would probably take less than 1 hour. Pressure checking methods of the actuator to the roof seal would have to be established since the entire reactor must be pressurized to properly check this seal.

3. Various cathode followers, relays, switches, and other miscellaneous electrical and instrumentation equipment. Redesign in a modular type of construction would allow remote replacement. Present hardware such as relays are of the plug-in type and can be replaced manually quite rapidly.
4. Wiring on the reactor/test car. Replacement of this wiring would be dependent on the extent of replacement necessary. It is quite possible that certain reassignment could be made in the privy from a damaged channel to a spare channel in a very short time. In any event, each case would require individual consideration.

To consider the manual repair approach mentioned above, one problem is how to get personnel safely into the privy. One method would be to construct a tunnel under the test cell pad to the bottom of the reactor/test car. With an entrance in the privy floor, personnel would be able to enter the privy safely. Another method would be to extend the privy roof shielding containing steel balls and water and perhaps increase its present 18-inch thickness so that a shielded manned vehicle could drive up and physically mate to the privy permitting a man to exit the vehicle and enter the privy safely. The privy doors, which swing open manually now, could be redesigned and motorized to be opened remotely. The Bat with some modifications might be useful to transport workers and Rad-Safe personnel to minimize exposure.

Category II

This category consists of the reactor/test car maintenance that might be performed at the test cell pad by

remotely operated manipulators or by shielded vehicles with manipulators. A specially designed pedestal-mounted model 2000 PaR manipulator has been recently loaned to us from the Lawrence Radiation Laboratory. It was designed for PLUTO reactor disassembly, but has never been used. We have not checked out this manipulator, but it is very possible that it could be used at the test pad and in the lower and upper disassembly bays. It has a 21-foot 7-inch reach horizontally and vertically, and if placed in the center of the lower disassembly bay, could touch both walls.

The operations that could be handled by these manipulators include:

1. Replacement of certain sections of low pressure cooling water piping on the test car. Quick disconnects might be considered here. However, by eliminating valves and other connections, this maintenance might never be required.
2. Opening and closing the present privy doors, which would decrease the radiation exposure of the personnel involved with the items listed in Category I above.
3. The replacement or plugging of holes for instrumentation such as pressure probes and temperature probes in the nozzle, propellant line, or pressure vessel, which might be possible with the proper assembly tools that can be handled by manipulators. These items would have to be readily accessible. Some of them have failed from heat and radiation on previous tests, but the test was not altered. It appears that the motions of the manipulations on the Beetle are too rough for such operations; but even though this has never been attempted, it might be possible, with some redesign.
4. Replacement of sections of tubing or fittings on pressure probe tubing. This appears to be a difficult operation, as poor visibility and limited working space would reduce reliability.

Category III

This category consists of the repairs and component replacements that might be performed remotely in the lower disassembly bay of the R-MAD Building, which has the most logical capabilities.

These items include:

1. Replacement of certain items of low pressure water piping that are beyond the capability of the Beetle or other shielded vehicles. It appears that this could be done at the present with existing equipment, either the overhead manipulator (O-Man) or one or both of the side-wall manipulators in the lower disassembly bay. Again, quick disconnects might be considered here.

2. Replacement of pressure transducer probes beyond the capability of the Beetle. At the present time this can't be done. However, the probes can be pinched or removed with little effort, but the data are then lost. Redesign is needed for replacement.
3. Replacement of temperature probes or plugging of their threaded holes in the nozzle, propellant line, or pressure vessel, which is again beyond the capability of the Beetle. Redesign is also needed here, although this might be performed now.
4. Replacement of certain sections of propellant system piping, which could possibly be performed now with some modifications. Figure 2 shows the somewhat critical alignment required to connect the 6-inch aluminum propellant riser to the reactor. It is connected 0.400 inches high as shown to reduce stresses in the spider connection. The pipe contracts to the approximate center line shown. The lower portion of the riser is set back 0.0625 inches, and contraction pulls the riser in to rest against a mechanical stop. The lower end of the riser connects with an 8-inch triple gimbal (not shown). A valve in the riser system, known as OBV-86, has since been eliminated from the test car. There is a vertical adjustment (not shown) which is conducted during the riser assembly. It is not known whether

Figure 2. Piping Alignment to Nozzle and Pressure Vessel

the tolerance of a spare propellant riser pipe would be exact enough for these dimensions. This riser pipe must be insulated with fiber glass, wrapped with fiber glass tape, painted to make it moisture proof, and covered with aluminum foil.

- Minor repair work or remote replacement in the privy of small electrical items such as solenoids and switches on the control actuators. This is unlikely due to limited working space and visibility. However, a special manipulator, perhaps the PaR mentioned in Item 1, equipped with a wrist-mounted TV camera might be able to do minor repair work.

Item 5 might be performed manually, however, in the privy with special movable shields for use in the disassembly bay. Perhaps a shielded cage, a lead box with a window, containing a man could be moved with the crane in the lower disassembly bay to the test car and placed under a redesigned over-hanging privy roof. This method would allow a man to enter the privy safely. However, one has the problem of gamma scattering here, and extensive shielding would probably be required on all sides of the privy. Again the amount of radioactivity is a big factor. But, for a test aborted very early, this might be possible.

Category IV

This category consists of those items connected with the replacement of a nozzle that cannot be repaired or replaced remotely with the Beetle or the existing remote handling equipment in the R-MAD Building.

Replacement of the nozzle remotely requires the disconnection and reconnection of many items and cannot be done with the present design (Figure 3). Here again is a nozzle view showing the various propellant connections: the 6-inch-diameter hydrogen propellant aluminum riser, the 6-inch flex line connecting the propellant line to the nozzle spider, the static seal, the propellant core screen, the 2-inch flex line, the clamp ring (belly band) coolant, the 1-inch nozzle bolt coolant line, the Marman type clamp segments, and bolts which fasten the connections. One end of the flex line is joined to the nozzle spider connection with a lead coated seal and eight $\frac{1}{2}$ -inch Allen head screws which are presently torqued from the spider side, making it impossible to get at remotely with an impact wrench. Reverse direction of these bolts and possibly larger diameter flanges will be required.

To remove the nozzle remotely, the nozzle instrumentation leads are presently cut, with the O'Man grinders, from the various pressure and temperature probes which are mounted into threaded bosses on the manifold, the spider, and the divergent skirt of the nozzle. These leads join others on the instrumentation

Figure 3. Exploded View of Propellant Piping Connections to Reactor

boom that connects into the privy terminal boards. Obviously, all nozzle instrumentation data would be lost as the leads cannot presently be replaced or rejoined remotely on a new nozzle.

A thin stainless steel nozzle shroud (not shown in Figure 3) protects the nozzle tubes against a liquid air-hydrogen leak or possible explosions such as those which have occurred on previous tests. The top of the shroud is welded above the nozzle throat, and the lower portion is bolted with a gasket to the aluminum pressure vessel. This enclosed volume is purged during a test. The nozzle bolts are located inside the shroud and cannot be seen or reached for removal. The shroud is presently removed remotely by making two cuts with a grinder. Elimination or redesign of the shroud would be required, probably with clamps and seals for disassembly and reassembly to the nozzle and pressure vessel. This could be a big reassembly problem for remote handling. Along with the shroud removal, the 6-inch flex line must be disconnected. A rubber coated stainless steel seal seals this connection, and a special fixture would be needed to replace this seal and to hold the line in position. The nozzle bolt coolant line is presently cut with the O'Man grinder during disassembly operation.

The nozzle bolts, some ninety-six 9/16-inch-diameter x 3-inch-long socket head cap screws, are removed with

Figure 4. Nozzle Installation

the side wall manipulator and impact wrench (see Figure 4). A redesigned nozzle using segment clamps similar to the clamp ring around the pressure vessel might be developed to hold the nozzle to the pressure vessel. However, two different materials are involved here, and sealing would be a problem. To replace the present screws would require, possibly, two or three guide pins spaced around the periphery bolt pattern on the nozzle to orient the theta = 0° position. These pins could be screwed in after three of the nozzle cap screws are removed during disassembly. These pins would guide the nozzle onto the pressure vessel. An impact wrench with a pre-set torque indicator could be used to replace the cap screws.

The large diameter lead coated Omega seal would have to be replaced in the pressure vessel seal groove before the nozzle is replaced. A small tool to pry up this 3/8-inch-wide seal for removal would be required as well as a special handling fixture to replace it. Manipulator handling would obviously damage a new seal, and a fixture must be capable of placing it in the pressure vessel seal groove.

After these reactor repairs are performed, tests would have to be conducted to ensure, insofar as possi-

ble, that the repair was successful. This would include pressure checking, continuity checking, or just a visual inspection. A nozzle pressure check might be conducted by capping the nozzle with a plate in some manner and pressurizing to some low pressure (25 psig) with a helium-freon mixture and using a halogen leak detector to check for leaks. This is the method presently used for leak checking the pressure vessel connections before mating to the test cart. An alternate method might be to pressurize with helium and check for leaks with a mass spectrometer. At a pressure of 25 psig, a nozzle cover similar to the one presently used could be installed and removed by the Beetle. Continuity checks could probably be conducted from inside the test cell.

It is unlikely that any further maintenance or component replacement would ever be attempted.

PREVIOUS EMERGENCY CONDITION

The following is an example of an emergency condition that existed on a previous test. During the recovery the B4D reactor/test car in May 1964, the radio-controlled locomotive malfunctioned and stopped about 600 feet from Test Cell "C" on its journey to the R-MAD Building. The test car could not be moved in either direction by radio. A team went in with a telescope for a close-up look to determine the trouble. Fortunately, the locomotive had stopped such that one of the photographic bunkers was conveniently located a few hundred feet from it. Personnel set up the telescope next to the bunker utilizing its earth shielding. After viewing the control panel through the window of the locomotive cab at 120 magnifications it was determined that a circuit breaker was tripped. An ACFI electronics technician went into the cab with the assistance of Pan Am Rad-Safe and LASL personnel and reset this circuit breaker. The radiation field was about 25 roentgens per hour in the cab which is shielded somewhat by its own structure. The technician was in the locomotive cab for 38 seconds and received about 200 milli-rem total dose. The locomotive was then started, and the trip to the R-MAD Building was completed. It was suspected that in climbing the incline at that location the circuit breaker had tripped due to an apparent current increase. Heavy duty circuit breakers have been installed in the locomotive, and this particular problem does not exist anymore.

CONCLUSIONS

Some remote maintenance on the Kiwi reactors at NRDS is possible with certain modifications and redesign of reactor hardware using present remote handling equipment. Additional maintenance and repairs might be possible by expanding the state-of-the-art of remote handling and by using exotic remote handling equipment and vehicles.