HEDL-7377

# PLANNING STUDY
# RESIN AND DEBRIS REMOVAL SYSTEM

# THREE MILE ISLAND NUCLEAR STATION UNIT 2 MAKE-UP AND PURIFICATION DEMINERALIZERS

## Hanford Engineering Development Laboratory


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Operated by Westinghouse Hanford Company
P.O. Box 1970 Richland, WA 99352
A Subsidiary of Westinghouse Electric Corporation
Prepared for the U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Office of Terminal Waste Disposal
and Remedial Action
under Contract No. DE-AC06-76FF02170
B&R No. AG-30-05

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June 1983

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## SUMMARY

Various methods were evaluated to remove the resin and debris from the makeup and purification demineralizers. There are two preferred concepts. The existing waste disposal system should be utilized if some contamination of currently clean lines is acceptable. A skid mounted, temporary, upflow/downflow system should be utilized if the demineralizers and associated piping are to be cleaned to the maximum extent practicable with minimum contamination of the existing system. Both methods provide for removal of complex organic compounds from the effluent and elution of Cesium from the resin. The resin and debris will be diluted with concrete to be disposed of in accordance with 10CFR61 burial limits.

# 1.0 INTRODUCTION

## 1.1 OBJECTIVE

This study evaluates options for removing resins, fuel, and debris from the pressurized water make-up and purification demineralizers MU-K-1A and -1B. The method of removal must accomplish the following functions:

1. Remove complex organic compounds from the demineralizer prior to releasing the effluent to the submerged demineralizer system.

2. Elute or rinse the $^{137}Cs$ from the demineralizer and its contents to minimize the activity of the waste products prior to their removal.

3. Minimize fuel fine contamination of the SDS prefilters.

4. Remove, package and dispose of the demineralizer contents as commercial wastes.

5. Flush the system.

## 1.2 BACKGROUND

Various approaches have been considered for resin removal as described in Reference 1. Numerous activities directed at assessing the contents of the demineralizer resulted in the estimates shown in Table 1. Los Alamos National Laboratory has made independent fuel assessments of the demineralizers and concluded that the maximum contained in "A" is 15.5 lbs and in "B" is 1.6 lbs. Apparently shrinkage of the resin bed has occurred. The shrinkage observed is approximately that produced in Pacific Northwest Laboratory (PNL) experiments at $1.7 \times 10^9$ rads, i.e. -56%. Visual observations by GPU have shown that the "A" demineralizer contains a dry caked resin and debris bed while the "B" demineralizer is approximately half-full of highly radioactive water, resin and debris.

TABLE 1

ESTIMATED DEMINERALIZER LOADINGS
BASED UPON MID-OCTOBER 1982 CHARACTERIZATIONS
AND APRIL 1983 SAMPLING OPERATIONS

| | Initial | A Vessel | B Vessel |
|---|---|---|---|
| 1. Resin | | | |
| Volume, $ft^3$ | 50 | 22 | 22 |
| Weight, lb | 2,139 | 1,025 | 1,025 |
| $^{137}Cs$, Ci | 0 | 3,500 | 7,000 |
| $^{134}Cs$, Ci | 0 | 270 | 540 |
| 2. Liquid | | | |
| Volume, $ft^3$ | 44 | 0 | 22 |
| Weight, lb | 2,746 | 0 | 1,373 |
| 3. Debris | | | |
| U, lb | | 5 | 1 |
| Core Debris, lb | | 95 | 19 |
| $^{137}Cs$, Ci | | 177 | 35 |
| $^{134}Cs$, Ci | | 16 | 3 |
| $^{106}Ru$, Ci | | 21 | 4 |
| $^{144}Ce$, Ci | | 28 | 5 |
| $^{125}Sb$, Ci | | 116 | 23 |
| TRU, Ci | | 0.5[(a)] | 0.1[(a)] |
| 4. Gas | | | |
| Volume, $ft^3$ | | 54 | 27 |
| Temp, $^{o}F$ | | 80 | 10.5 |
| Pressure, psig | | 11 | 10.5 |

(a) $\alpha$ activity only

A study by Westinghouse Hanford evaluated integrated doses at certain equipment locations within the "A" demineralizer cubicle. Results of this evaluation are shown in Table 2. Of particular concern for resin removal were the condition of the valves associated with the resin fill and sluice lines. The table shows that dose rates have not reached the range where operation would be affected. Dose rates were estimated from radiation surveys and extrapolated back to the accident based on GPU estimates of isotopic concentrations to establish integrated doses. If, as estimated, the "B" cubicle contains twice the activity in approximately the same location, integrated doses will approach twice the value shown for the "A" cubicle. Sampling operations in April 1983 demonstrated that the resin fill line valves in both cubicles would open using normal controls.

The amount of debris in the lines leading to each demineralizer is somewhat uncertain. Letdown flow has been circulated subsequent to the accident through the line which bypasses the demineralizers and their inlet filters. Flushing operations were performed in October 1980. However, the makeup and purification filters and demineralizers have been isolated for an extended period of time. Resin sampling operations conducted in March and April, 1983, through the resin fill lines, removed standing water. Gas sampling operations of both demineralizers were conducted in February 1983, using the normal inlet and outlet lines. The demineralizers were subsequently purged with nitrogen. Gas generation rate measurements are planned to be measured in the near future.

## 1.3 SCOPE

Various options for removal of resin and debris are identified in this study. The three options which were considered to best meet the technical objectives are evaluated in detail. Each option includes design, fabrication and installation of equipment; training and operation; and packaging, shipping and disposal.

TABLE 2

COMPONENT STATUS - "A" CUBICLE

| Equipment # | USE | "A" CUBICLE CURRENT DOSE RATE, R/HR | INTEGRATED DOSE, $10^7$ RADS | PROGNOSIS |
|---|---|---|---|---|
| MU-111A, GRINNEL | RESIN FILL VALVE | 510 | 8.3 | NORDELL DIAPHRAGM PROBABLY USABLE |
| MU-R5A, CROSBY | PRESSURE RELIEF | 400 | 6.6 | METAL OR BUNA-N SEAT - ACCEPTABLE |
| MU-V1116A, VELAN | GAS VENT | 530 | 8.7 | PROBABLY ACCEPTABLE |
| MU-217A, VELAN | GAS VENT | 510 | 8.3 | PROBABLY ACCEPTABLE |
| MU-V192A, VELAN | LIQUID SAMPLE TAP | 500 | 8.1 | PROBABLY ACCEPTABLE |
| MU-V194B, VELAN | $\Delta$P Line | 650 | 10.5 | PROBABLY ACCEPTABLE |
| MU-V194A, VELAN | $\Delta$P Line | 250 | 4.2 | PROBABLY ACCEPTABLE |
| MU-V193A, VELAN | LIQUID SAMPLE TAP | 300 | 5.1 | PROBABLY ACCEPTABLE |
| MU-V108A, GRINNEL | RESIN SLUICE | 650 | 10.5 | PROBABLY ACCEPTABLE |
| MU-V238A, GRINNEL | RESIN SLUICE | 600 | 9.9 | PROBABLY ACCEPTABLE |
| MU-V240A, VELAN | DRAIN LINE | 300 | 5.1 | PROBABLY ACCEPTABLE |
| MU-V109A, VELAN | DRAIN LINE | 300 | 5.1 | PROBABLY ACCEPTABLE |
| B&W MU-8 PI-1 | DIFFERENTIAL PRESSURE SWITCH | 200 | 3. | PROBABLY ACCEPTABLE |

## 1.4 CRITERIA

Various technical and non-technical criteria were established for the purpose of evaluating the alternatives. These criteria are described below. The evaluation of each alternative has been based upon the assumption that the waste will be diluted, where possible, for commercial disposal in accordance with the standards established by 10CFR61.

### 1.4.1 Cost

Each alternative has been evaluated on a total cost basis, i.e., the cost of design, fabrication, installation, implementation, removal, shipment and disposal. The estimated costs of equipment and manpower requirements are based upon conceptual technical studies. Consequently, only a relative cost comparison is made.

### 1.4.2 Schedule

For the purposes of this study it has been assumed that all efforts to remove the resin and debris will be performed on a non-interference basis with other recovery efforts. The goal is to have the resin and debris removed from the demineralizers by late 1984.

### 1.4.3 Space Allocation

Equipment to remove the resin and debris must be located in areas where assembly, operation and removal activities will not conflict with other TMI-2 recovery activities. Tie-in points and piping runs must be accessible. Interim storage locations for removed resin must be available to allow decoupling of the resin removal process from shipping turnaround cycles.

### 1.4.4 Fuel/Radioactivity Removal

The capability of each approach to remote resin, fuel, and debris from the makeup and purification demineralizers, and also leave other TMI-2 systems clean, is evaluated for each approach.

### 1.4.5 Technical and Operational Risk

Several risks are inherent in the alternatives to be evaluated:

A. The condition of the demineralizer contents has been assessed by WHC, GPU and ORNL. These tests have provided much data, but uncertainties about resin sluicability, liquid organic compound content, resin elution capability, and fuel content cause any removal system concept to have some risk of not succeeding.

B. Some required plant systems or equipment have not been operational for over four years. These systems, in varying degrees, will have to be made operational for any resin removal system to operate effectively.

### 1.4.6 Exposure (Man-Rem)

Exposure can occur during equipment installation, operation or equipment removal. Although radiation surveys of each tie-in point have not been specifically made, general area surveys have been utilized to pick tie-in locations with low exposure. All of the systems under consideration would be shielded to allow routine access during operation. Therefore the degree of exposure is primarily dictated by the amount of temporary piping and equipment which must be subsequently disassembled and prepared for disposal. Exact Man-Rem values have not been calculated, but relative exposure amounts can be assessed.

## 1.5 APPROACH

There are various approaches to the resin and debris removal problem, with alternative methods of accomplishing each approach. The three most promising approaches are listed below:

<u>Approach A</u> Install a hydro-mechanical device into the demineralizer through the resin fill line. Remove the contents to a container for dewatering and subsequent shipment.

<u>Approach B</u> Utilize the existing waste disposal system by sluicing the demineralizer contents to the spent resin storage tank WDS-T-1B and then transferring the contents to a portable concreting system.

<u>Approach C</u> Install a temporary processing system which will carefully control each removal operation. Resin and debris are removed to an interim storage container then subsequently transferred to a portable concreting system.

SECTION 2.0

## 2.0 RECOMMENDATION

Two methods of removing resin and debris from the make-up and purification demineralizers are considered to be preferred concepts. The existing waste disposal system should be utilized if some contamination of currently clean lines is acceptable. A skid mounted, temporary, upflow/downflow system should be utilized if the demineralizers and associated piping are to be cleaned to the maximum extent practicable with minimum contamination of the existing system. Both of these recommended alternatives will accomplish the functions listed in Section 1.1. Utilization of the existing system can be accomplished at a low relative cost and the shortest schedule while cleaning to the maximum extent practicable with the temporary upflow/downflow system is more expensive and has a longer schedule. Both of these methods require the operation of existing valves and control systems. The costs to make these operational have not been considered since it is assumed that these costs would be incurred as a part of other normal TMI-2 recovery efforts.

Table 3 provides a comparison of all considered approaches against the criteria described in Section 1.4.

TABLE 3

EVALUATION SUMMARY

| | COST | SCHEDULE | SPACE ALLOCATION | FUEL/RADIOACTIVITY REMOVAL | TECHNICAL/ OPERATIONAL RISK | EXPOSURE |
|---|---|---|---|---|---|---|
| Mechanical Tank Removal | Highest. Need to replace tanks. | Greater than 24 MOS | No Interim Storage Avail. | | Very High. May Not Be Able to Get Tanks Off Island | Very High |
| Chemical Treatment | High | Greater than 24 MOS | Not Evaluated | May Leave Some Debris in Tanks | Very High. Complex Temperature and Chemical Controls | Moderate |
| Hydro/ Mechanical | Low | 12-15 MOS to Resin Removal | Equipment in Hays Gas Anal. Rm. (305' Elev.) | Hit/Miss System will leave some debris in tanks. Particle Size Limited | Requires design, fabrication and test of new equipment. | Moderate |
| Existing System | Low to Medium | 9-12 MOS to Resin Removal | Portable Concrete Syst. in Model Rm (305' Elev.) | Will clean tanks. Drop-Out in Dead Legs Will Cause Hot Spots in Currently Clean Piping | Some chance of plugging sluice line. High technical risk for TRU measure device. | Lowest if liquid activity reduced or loca shielding added in access areas |
| Skid Mounted Upflow/ Downflow | High | 15-18 MOS to Resin Removal | Skid in Hays Gas Anal. Rm (305 Elev.) or Outside Make-Up Pump Rm (280'6" Elev.). Portable Concrete Syst. in Model Rm (305' Elev.) | Best: Will Clean Tanks and Sluice Line. May Clean Inlet and Laterals | Low operational risk if sluiceable. High technical risk for TRU measure device. | Moderate. Long Runs of Contaminated Pipe Require Disposa |

# SECTION 3.0

## EVALUATION

Various approaches to resin removal were evaluated by Westinghouse Hanford Co. An overview is given of the approaches which were judged to be unacceptable during the initial conceptual design studies. A more detailed evaluation is presented of the three approaches discussed in Section 2.0.

### 3.1 PHYSICAL TANK REMOVAL

Removal of the demineralizer tanks in shielded containers was evaluated but was eliminated early in the design process. The high radiation dose rates in the demineralizer cubicle would make access possible only by remote means. Pipes would have to be severed and capped, walls penetrated, shielding and transportation devices designed, fabricated and tested. It was concluded that personnel exposures would be high and building operations severely restricted because of the high potential for contamination.

Costs would be high since tank replacement and significant building modification would be required. A special interim storage area would have to be constructed on-site because of the high activity levels. Transportation off-site is probably not possible without reducing the activity of the demineralizer contents. The significance of these problems led to the conclusion that removal is not technically viable.

### 3.2 IN-SITU TREATMENT

Four areas of in-situ treatment were considered: dissolution; solidification; acid digestion; and chemical oxidation/dissolution. Of these, chemical oxidation/dissolution was determined to be the most feasible.

Laboratory scale tests showed that the most promising resin oxidation/dissolution process was the iron-catalyzed, hydrogen peroxide system. The hydrogen peroxide reverses the polymeric process and breaks up the cross-linkages that link the resin monomers together. Resin reaction parameters determine the amount of degradation that occurs. Resin may merely be degraded to fine pumpable solids or the resin may be degraded to polymer chains small enough to completely dissolve in the reaction media. Several WHC lab tests were run with encouraging results. The resin was rapidly degraded at reasonable temperatures ($\leq 90^{o}C$) and concentrations ($\leq 15\%$ $H_2O_2$). The rate appeared to be controllable by manipulating temperature and concentration. However, this system may have difficulties converting melted or charred resin because of the reaction mechanisms.

Use of concentrated sodium hypochlorite solution (12-15% chlorine) was also investigated. Sodium hypochlorite apparently breaks up monomer chains as well as cross-linkages. It will also react with carbonized resin (elemental carbon). However, the overall reaction rate for the sodium hypochlorite system was substantially slower than for the corresponding hydrogen perioxide system.

If the resin is considered fully degraded and carbonized, then a high temperature dissolution such as sulfuric-nitric acid at about $250^{o}C$ ($480^{o}F$) is preferred. If this seems too difficult then the low temperature sodium hypochlorite dissolution should be considered with provision for lengthly digestion times and lots of liquid reactant.

The results of the resin characterization program indicated that the demineralizer contents would most likely be sluicable. Also, there was a major concern that liquid wastes would not be compatible with SDS. Therefore, this approach was not given further consideration.

## 3.3 HYDROMECHANICAL SYSTEM

The hydromechanical system provides for the removal of complex organic compounds from the demineralizer effluent prior to sending the effluent to the SDS and EPICOR-II water treatment systems. The hydromechanical removal system also provides for elution of the resin bed with chemicals and processed water to remove $^{137}Cs$ prior to transferring the resin and debris to the shipping containers. The concept uses a high velocity water stream to breakup the resin bed. A suction hose is used to remove the resin and debris. Waste is shipped in a dewatered form. Final steps in the process are a flushing operation with a high pressure water lance and a rinsing operation with demineralized water to wash residual resin and debris from the interior surface of the demineralizer vessel. The individual steps of the process are as follows:

### 3.3.1 Removal Procedure

Step 1. Remove Complex Compounds and Cesium (See Figure 1)

Water is added to the demineralizer and a nitrogen sparge is initiated to break-up the resin bed. Water containing eluents is added to the demineralizer. After the bed has settled, liquid is removed very slowly (less than 5 gpm) through the suction hose and pumped through the shipping container and charcoal filter. The charcoal filter will capture any complex organic compounds prior to the effluent being sent to the reactor coolant bleed hold-up tanks for subsequent processing by SDS and EPICOR II. The fill, sparge, and drain sequence is repeated until no further reduction in gamma radiation is noted in the demineralizers.

Step 2. Remove Resin and Debris (See Figure 2)

A water lance and the suction hose are inserted to the surface of the resin bed. The bed is agitated by the high pressure (approx. 1000 psi) water lance and nitrogen sparging. Resin and debris are removed through the suction hose into the shipping container. A 10 micron filter separates the resin from the effluent which flows through the charcoal bed containing a 1 micron filter. The lance and suction hose are moved about until no further resin and debris are observed in the removal line. Demineralizer tank interior cleanliness is visually checked with fiber optics equipment.

## REMOVE COMPLEX COMPOUNDS AND CESIUM

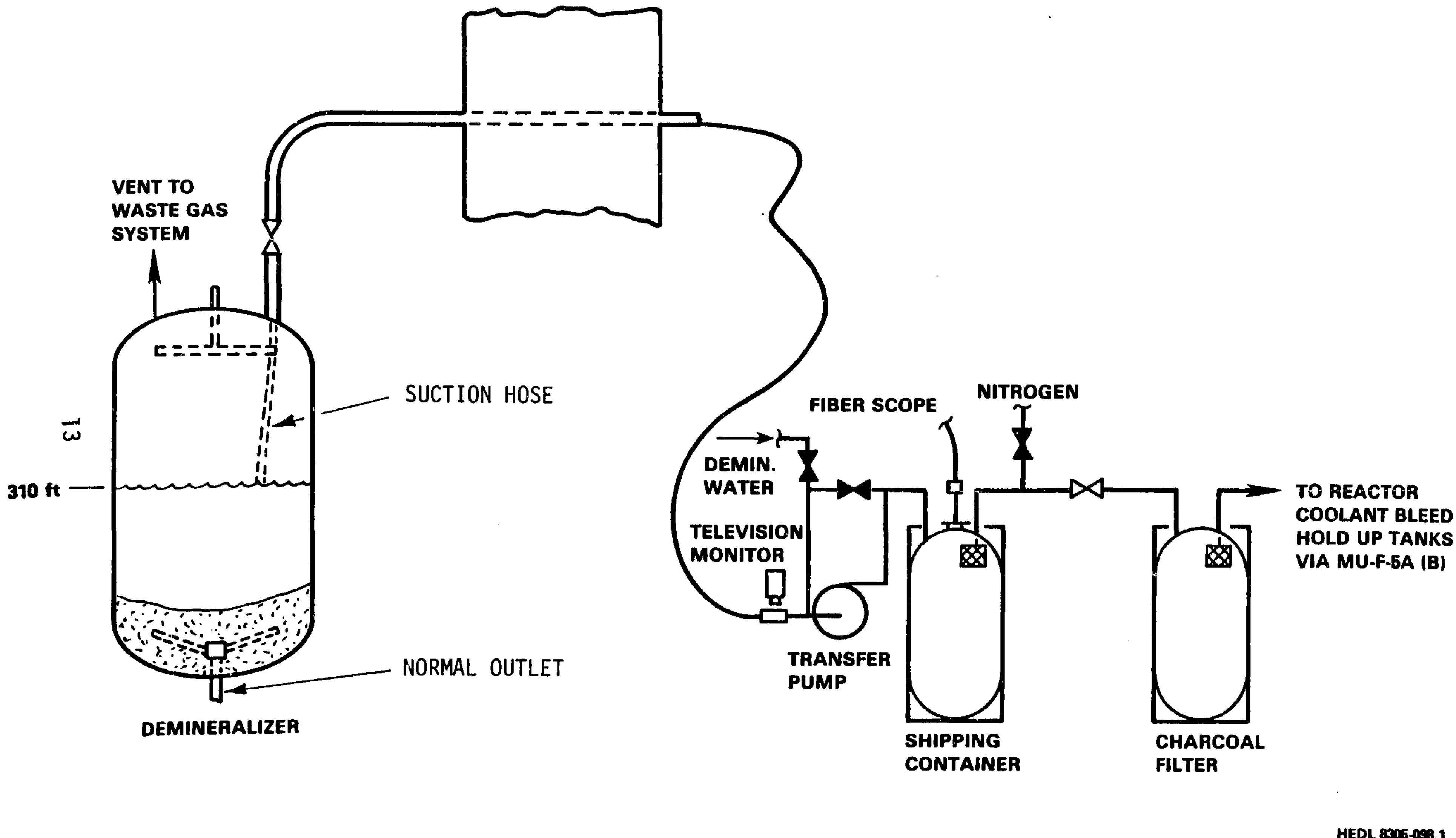


FIGURE 1. Remove Complex Compounds and Cesium.

## REMOVE RESIN AND DEBRIS

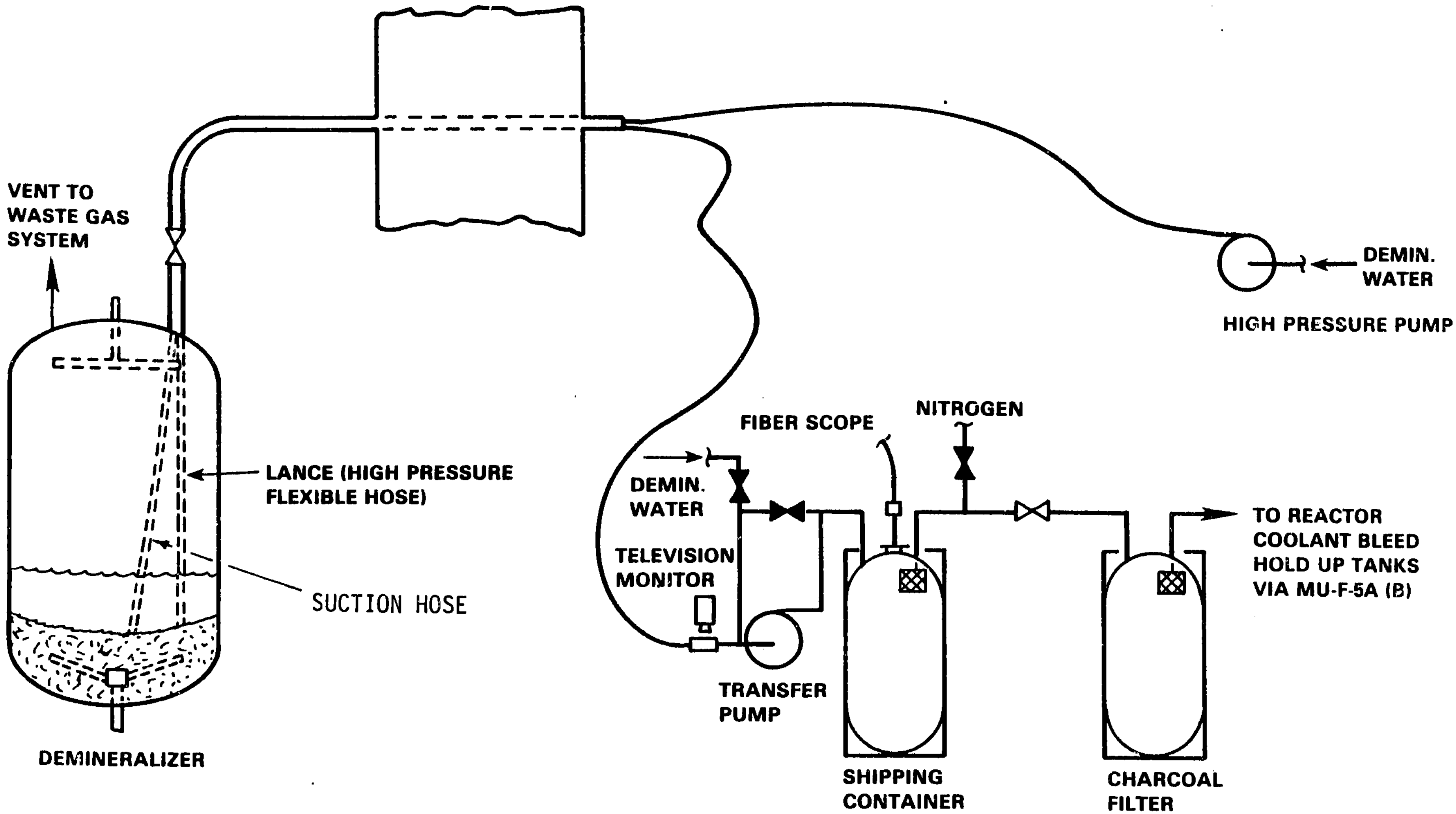


FIGURE 2. Remove Resin and Debris.

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Step 3. Final Flush of Demineralizer (See Figure 3)

By inserting the suction hose to the bottom of the tank while raising and lowering the water lance, the walls of the demineralizer can be cleaned. The success of this operation can be verified by use of the fiber optics.

Step 4. Shipping Container Change-out

Since the demineralizer contents exceed the volume of the shipping container (modified SDS liner), several shipping containers will be required for each demineralizer. When the shipping container is found to be full, it will be backflushed with nitrogen, a check will be made on resin level, and then an empty container will be installed.

This procedure is based upon the assumption that the resin is shipped for disposal in a dewatered state. The resin could also be solidified in concrete by utilization of the systems described later in this study.

### 3.3.2 Advantages and Disadvantages

The hydromechanical system has the following advantages and disadvantages:

Advantages

1. The required equipment (including temporary piping) is minimal; therefore, cost is relatively low.

2. Equipment is small in size; therefore, all items could be located in the Hays gas analyzer room without removing knock out walls and instrumentation. The ability to place all process equipment in the Hays gas analyzer room eliminates possible interference with other clean-up operations at TMI-2.

3. Tie-in points to existing piping system are readily accessible.

FINAL FLUSH OF DEMINERALIZER

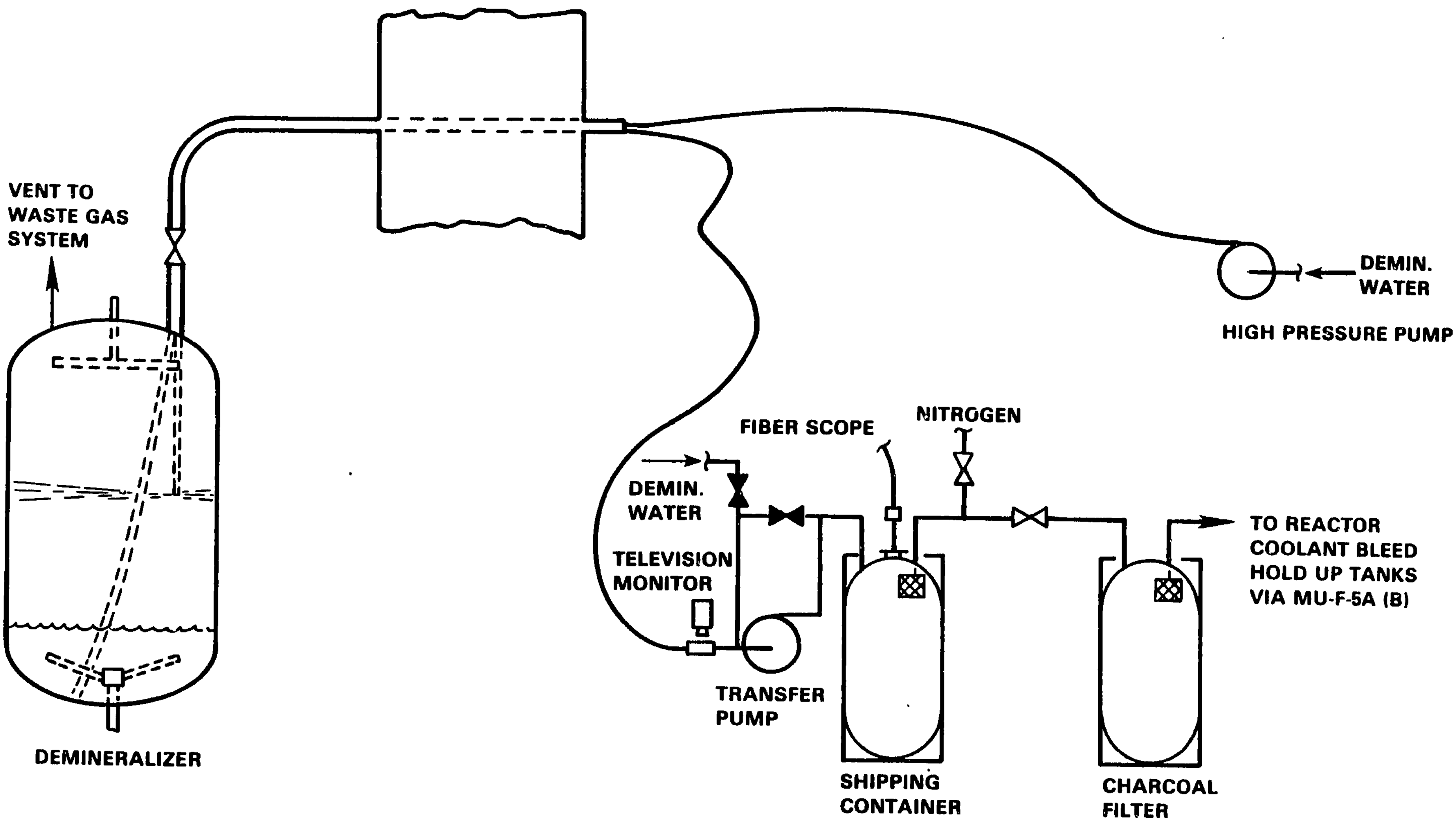


FIGURE 3. Final Flush of Demineralizer.

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Disadvantages

1. System operators cannot see the resin bed or the position of the lance. The process will be very time consuming (hit and miss) with regard to resin and debris removal. A Fiberscope will be required to inspect the interior of the demineralizer visually to determine progress of clean-up operation.

2. Resin and debris cannot be removed from the 3-inch diameter resin outlet line at bottom of demineralizer.

3. Water level or water volume inventory system must be employed to assure that demineralizer is not overfilled with resultant spill of contaminated water out the resin fill line.

4. Requires use of existing vent lines from top of demineralizers to vent cover gas. The valves in these vent lines may not be operable.

5. There is a risk that the lance could get hung-up and be impossible to remove.

Based upon the above discussion and the GPU experiences during resin sampling, this approach is not considered acceptable.

## 3.4 TEMPORARY UPFLOW/DOWN FLOW REMOVAL SYSTEM

The temporary upflow/downflow method of resin and debris removal is accomplished in three phases. Phase I provides for the removal of complex organic compounds and cesium. During Phase II the resin and debris are removed to a transfer container. The resin and debris are mixed with concrete for shipping and disposal in Phase III. The temporary upflow/downflow removal system provides for control of each aspect of the removal process with a minimum contamination of existing TMI-2 piping.

### 3.4.1 Phase I (See Figure 4)

Complex organic compounds and cesium are removed from each demineralizer by the addition of water (and chemicals, if necessary) through the normal outlet. The resin bed is agitated by a nitrogen sparge. After the bed has settled the water is removed, filtered, and sent to the reactor coolant bleed hold-up tank. The water addition, agitation, settling and removal steps are repeated until the organic compounds and cesium are removed. All flows during this phase are at less than 5 gpm to minimize any carry-over of resin and debris. Should any carry-over occur, it will be captured by a 1 micron filter and subsequently back-flushed into the demineralizer.

### 3.4.2 Phase II (See Figures 5 & 6)

Upon completion of Phase I, resin and debris removal can be initiated. The equipment to accomplish this phase can be located in the Hays gas analyzer room (305' elev.) or outside the make-up pump room (280'6" elev.).

The recirculation pump is started to establish a fast (120 gpm) flow rate in an upward direction through the demineralizer. Some resin and debris will overflow into the resin fill line (tests indicate approximately 700% expansion of resin bed). Resin and large particles of debris that overflow will be collected in the resin transfer container which includes built-in 100 mesh (150 micron) screen to retain resin beads. Most debris (including fuel fines) will settle to bottom of the resin transfer container. Some fuel fines and debris smaller than 150 microns will pass through the 100 mesh screen and will be recirculated through the demineralizer. This process continues until gamma radiation levels in the demineralizer cubicle stabilize, which indicates that no additional resin is being transferred from the demineralizer. The remaining resin and debris must be removed by downflow.

Downflow is initiated by lowering the water level in the 300 gallon surge tank. Water is then injected into the bottom of the demineralizer through the normal outline line to create a slurry in the demineralizer. In parallel with this

# REMOVE COMPLEX COMPOUNDS AND CESIUM

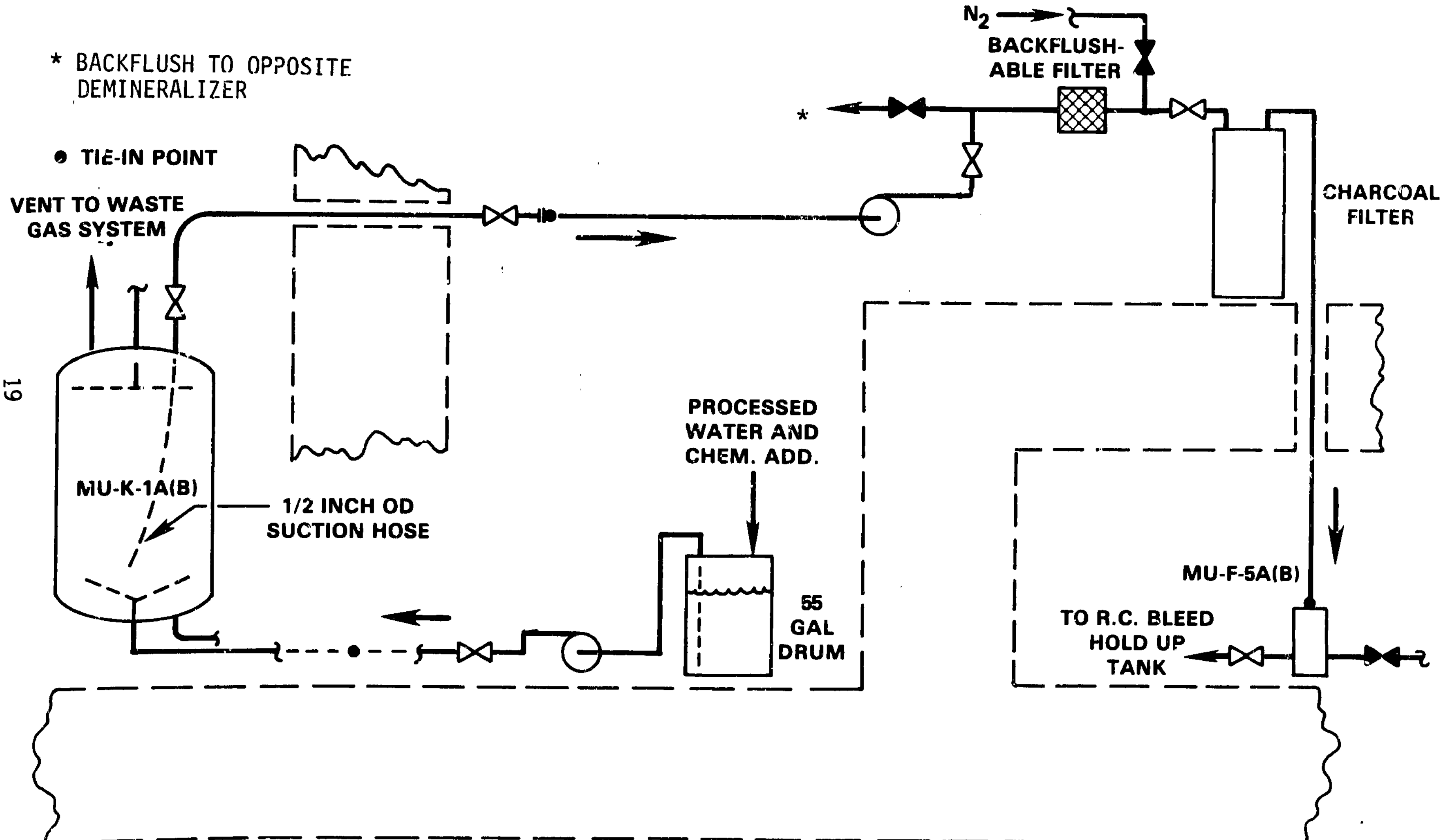


FIGURE 4. Remove Complex Compounds and Cesium.

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# FAST UPFLOW

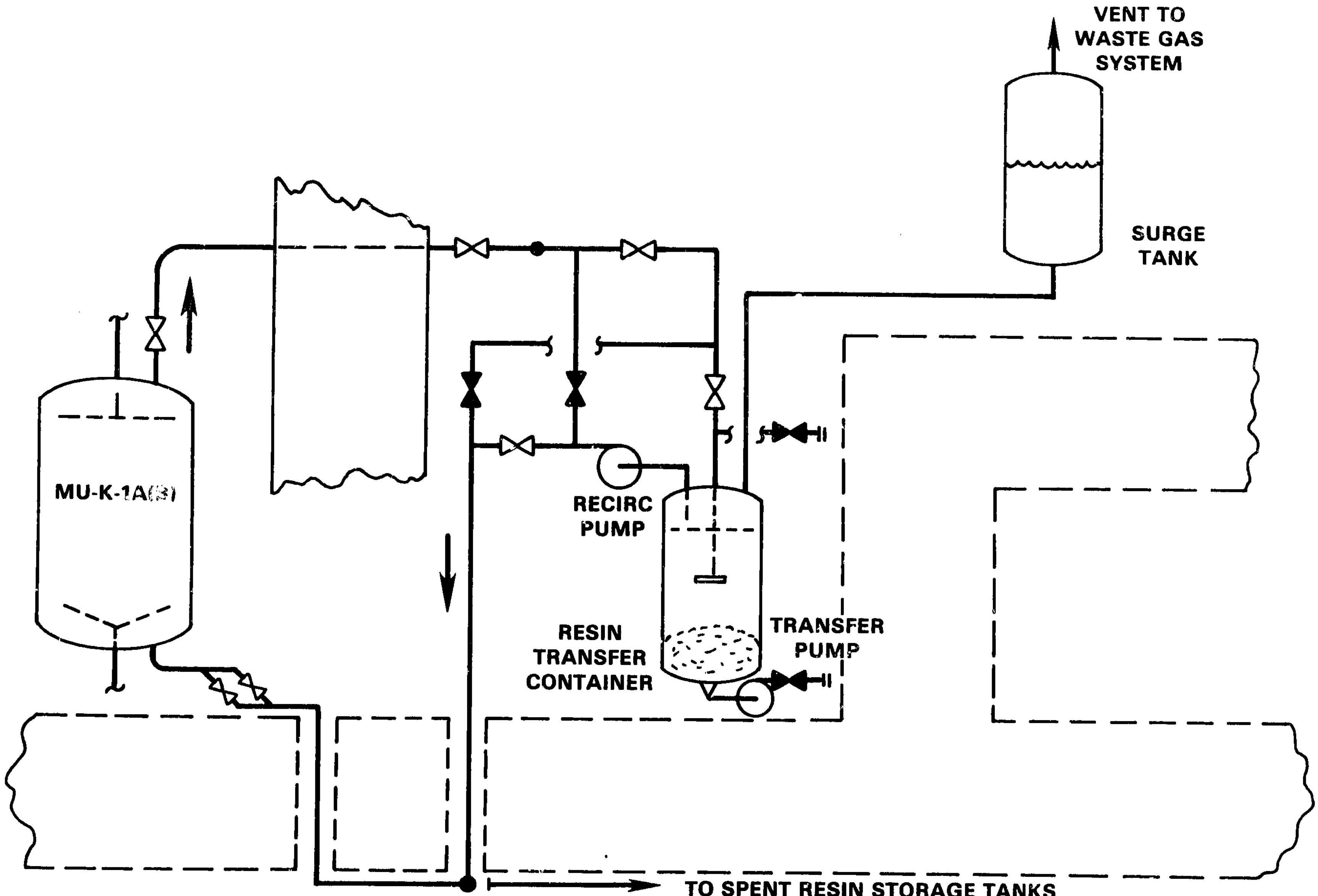


FIGURE 5. Fast Upflow.

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# FAST DOWNFLOW

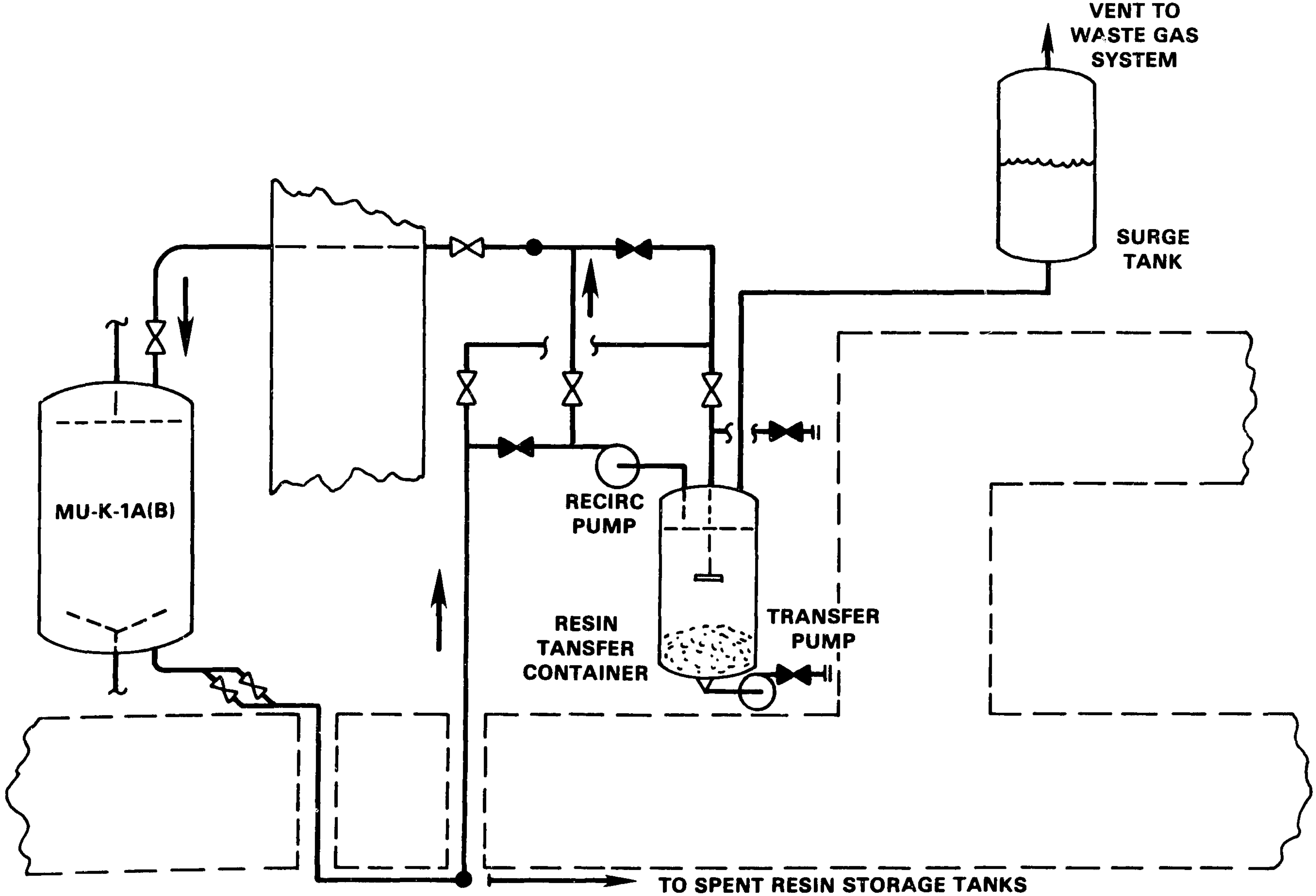


FIGURE 6. Fast Downflow.

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step, fast upflow is initiated to clear the resin sluice line of resin and debris upstream of valves MU-V108 and MU-V-238. Upflow and injection of demineralized water is secured when the water level in the surge tank approaches the high level alarm point. Immediately thereafter fast downflow is initiated by changing valve positions and restarting the recirculation pump. Fast downflow recirculation is continued until all resin and debris have been sluiced from the demineralizer.

### 3.4.3 Phase III

When sufficient resin and debris have been accumulated in the resin transfer container a recirculating slurry is established between the temporary concreting station in the model room (305' elev.) and the transfer container (see Figure 7). The resin and debris are then transferred into the concreting container until either 2200 Curies of activity are accumulated or sufficient $^{144}$Ce to indicate that the 100 nCi TRU/g limit has been reached. The resin and debris are then dewatered and solidified in concrete. Based upon the non-TRU activity shown in Table 1, it is estimated that 6 liners of approximately 60 cu. ft. can accommodate the waste from both demineralizers. If rinsing or eluting the resin/debris bed is effective, the number of containers could decrease. If shipment must be made to U. S. Ecology, whose requirements are more stringent than 10CFR61, the number of containers may increase to as many as 48. As each liner is solidified, it can be placed in an interim storage area, thus decoupling the resin removal process from the two week shipping cycle.

A GPU proposed alternative concept (Figure 8) for concreting the resin and debris in 55 gallon drums and the loading station could be located at the north end of the 280' 6" level. The recirculating slurry would be established between the transfer container and the concreting station. A batch of slurry would be added to the conical shaped tank and allowed to settle. Liquid would then be decanted from the solids. This batching would be continued until the cone was filled with solids at which time the curie and TRU content would be measured. Assurances would be made that the end product would be within

# RESIN AND DEBRIS TRANSFER TO SHIPPING CONTAINER

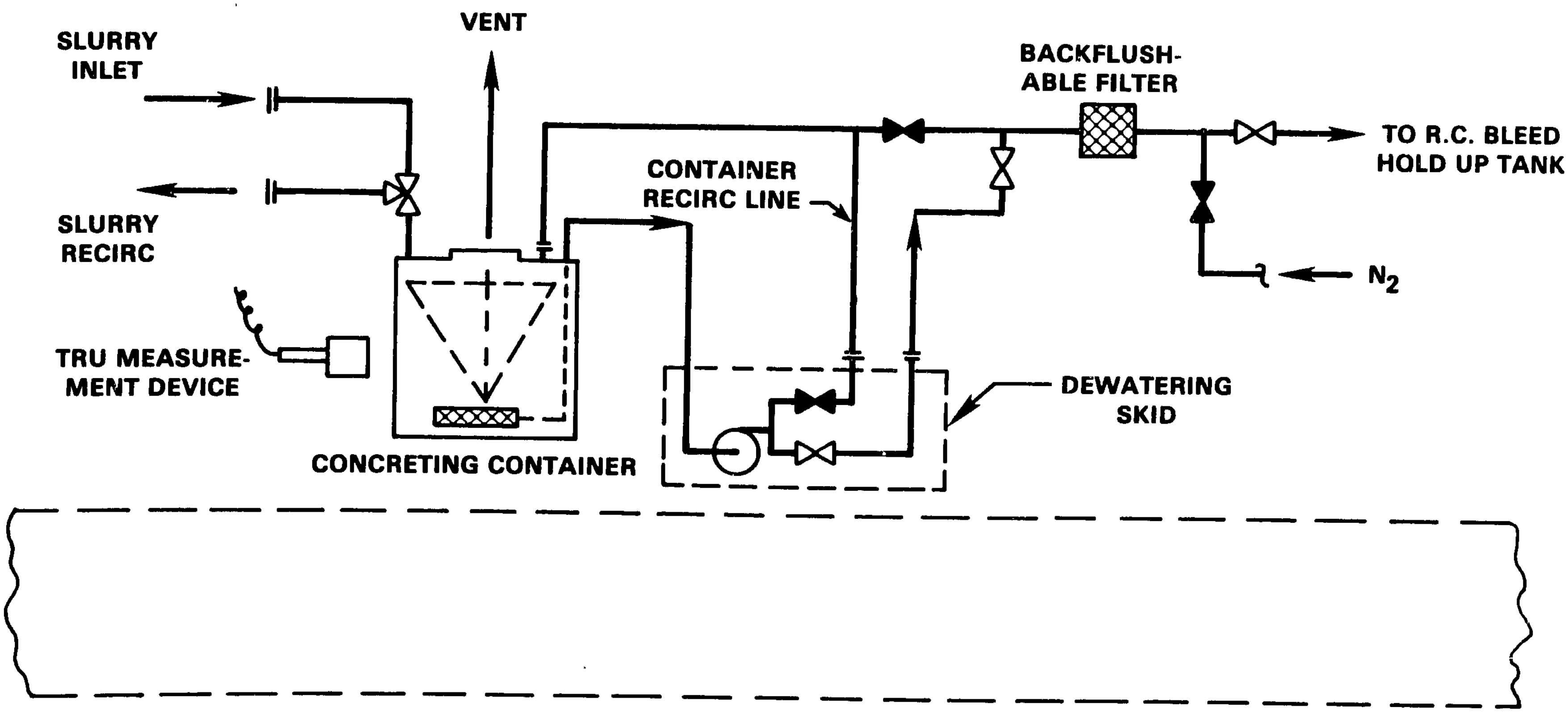


FIGURE 7. Resin and Debris Transfer to Shipping Container.

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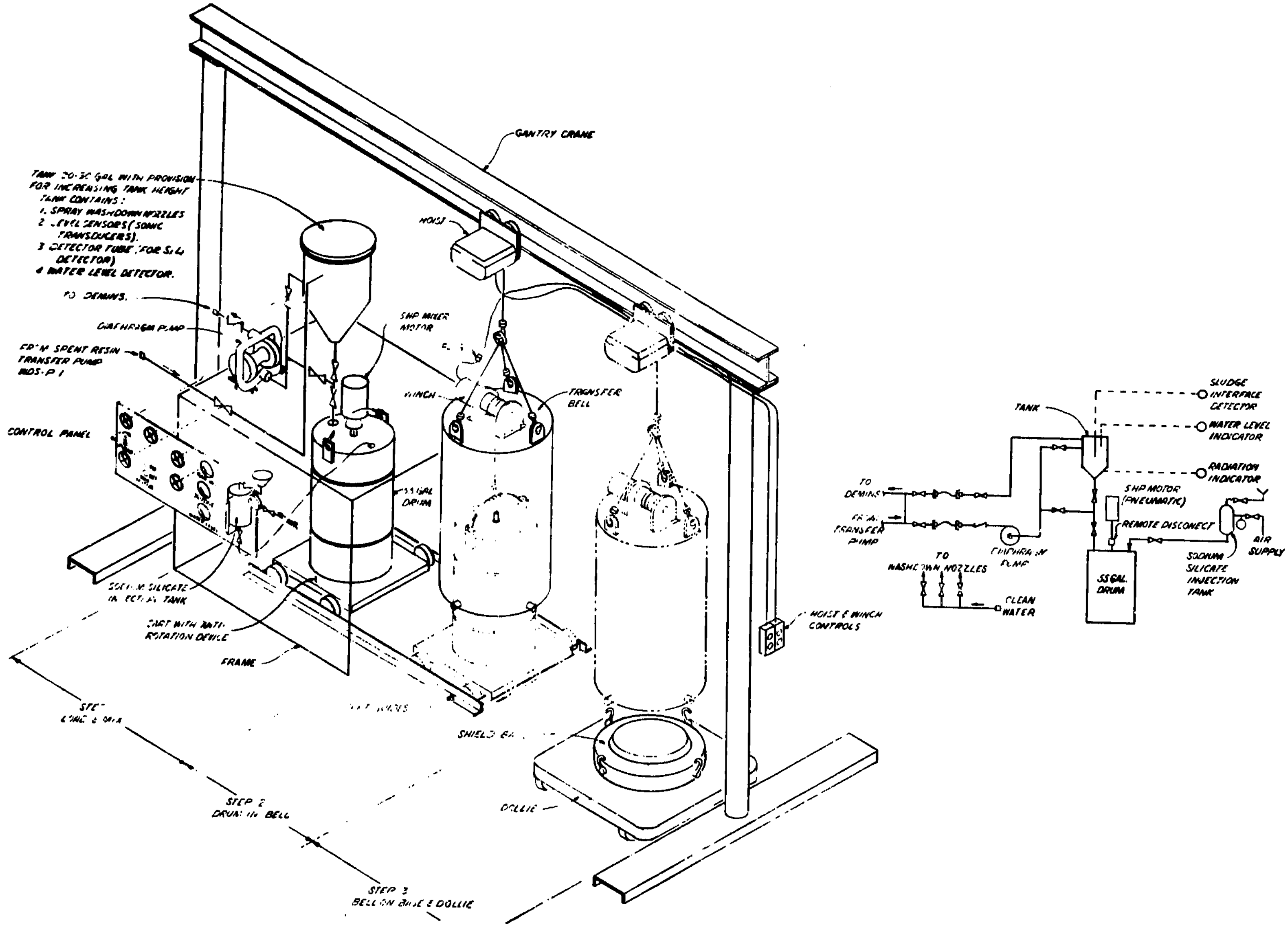


FIGURE 8. GPU Alternate Concreting Station.

10CFR61 limits prior to releasing the contents to the 55 gallon drum. Solidification would take place in the 55 gallon drum and the solidified waste would be placed in an interim storage area. Approximately 50 drums are required to accommodate the non-TRU activity shown in Table 1. This could increase to about 390 drums if U. S. Ecology license limits for TRU are applied.

### 3.4.4 Advantages and Disadvantages

The temporary upflow/downflow system has the following advantages and disadvantages:

Advantages

1. Allows controlled transfer of resin and debris during fast upflow.

2. Minimizes risk of plugging the resin sluice line during fast downflow.

3. Does not contaminate the Waste Disposal System and assures the cleanest plant condition of demineralizers and associated piping.

Disadvantages

1. New piping, tanks and associated equipment require design, fabrication, and testing which results in an extended schedule.

2. Relatively high costs.

3. Removal of temporary piping and equipment has some Man-Rem exposure risk.

4. The resin and debris are assumed to be sluicable.

5. A TRU measurement system must be designed, fabricated, and tested.

## 3.5 USE OF EXISTING SYSTEMS

The demineralizer resin and debris can be removed utilizing the existing systems for resin sluicing and solidification. This process again consists of three phases with Phase I and III being as described previously in Section 3.4. Once cesium and complex organics have been removed, the resin and debris are sluiced to the spent resin storage tank. The resin and debris can then be transferred in a slurry to a temporary concreting station in the model room at the 305' elev.

### 3.5.1 Removal Procedure (See Figure 9)

When the cesium and complex organics have been removed from the resin and debris, they can be sluiced to the spent resin storage tank as follows:

Add nitrogen and demineralized water to demineralizer through the normal outlet line to generate a resin slurry. Then add demineralized water to the demineralizer through the sluice line using the existing connection to the sluice line header. This will unpack resin in the resin sluice line upstream of valves MU-V108 and MU-V238. Monitor the pressure increase in the demineralizer until it reaches approximately 75 psig. Then secure the water to the sluice line and open the inlet valve to the spent resin storage tank WDS-T-1B. Attempt to maintain 75 psig in the demineralizer by throttling nitrogen and demineralizer water valves. If the pressure goes to zero, the contents have been transferred to the spent resin storage tank. If the pressure remains constant with MU-V114 and MU-V-292 shut and the sluice line valves open, the sluice line is plugged. The estimated quantity of demineralized water required to sluice resin and debris from each demineralizer is 1200 gallons.

Once the resin and debris are in the spent resin storage tank they can be transferred to the concreting station. Generate a slurry by adding demineralized water and adding nitrogen. Vent gas from spent resin storage tank to waste gas system. Add water at a rate of 50 gpm for 20 minutes (1000 gallons). The spent resin storage tank will now contain approximately 2200 gallons of

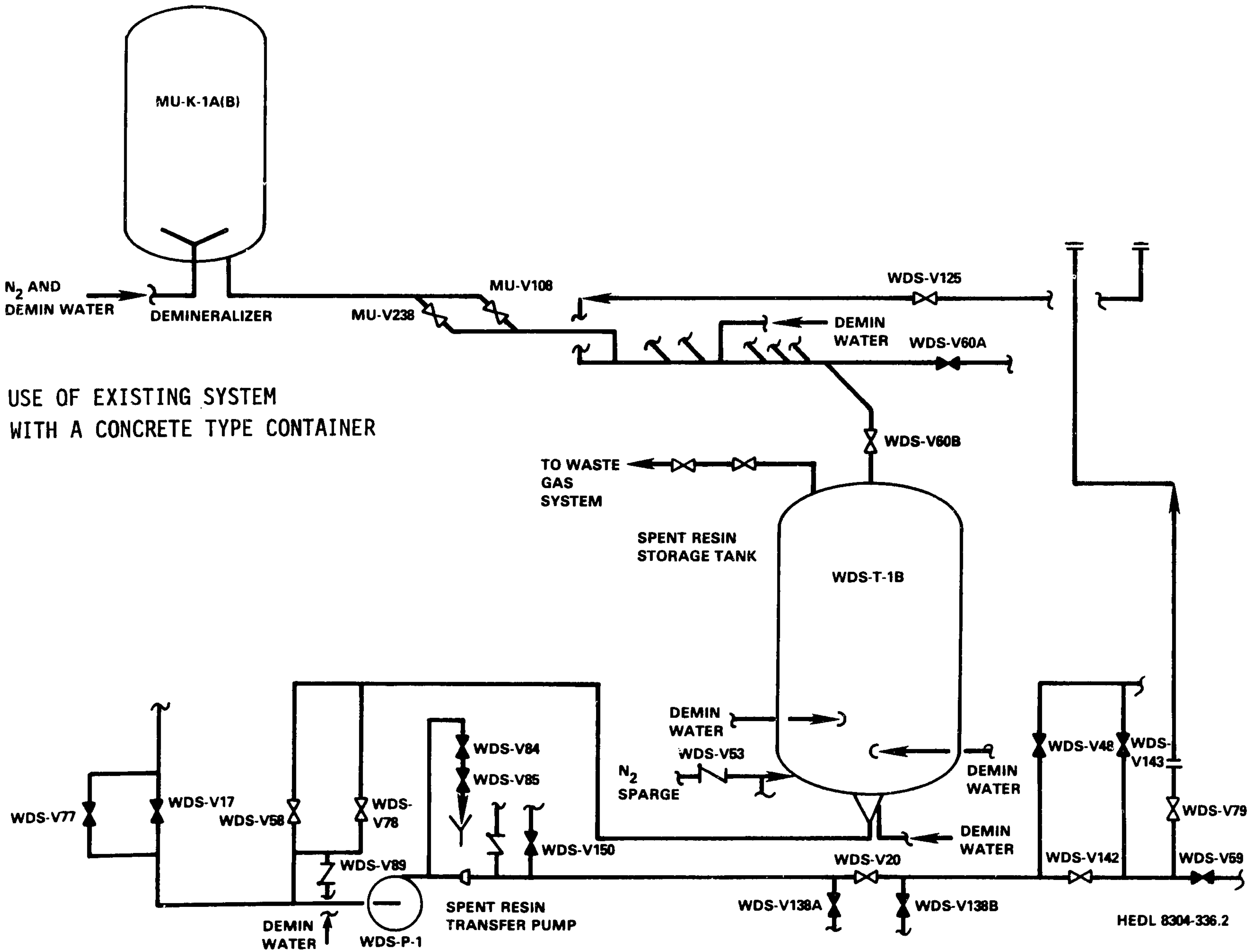


FIGURE 9. Use of Existing System

water (capacity is 3861 gallons). Continue to sparge with nitrogen to maintain slurry and then pump the slurry to the temporary concreting system located in the model room through the existing piping intended for this purpose. The solidification process is as described in Section 3.4.

### 3.5.2 Advantages and Disadvantages

Utilization of the existing systems has the following advantages and disadvantages:

Advantages

1. Has the shortest schedule for resin removal.
2. Utilizes many normal TMI-2 procedures for resin removal.
3. Relatively low cost.

Disadvantages

1. Contaminates existing clean piping, tanks and equipment.
2. Assumes resin and debris are sluicable.
3. Greater risk of plugging sluice line since all contents are removed at once.
4. A TRU measurement system must be designed, fabricated, and tested.

## 4.0 REFERENCES

1. M. K. Mahaffey, et al, Resin and Debris Removal System Conceptual Design, HEDL-7335, Hanford Engineering Development Laboratory, Richland, WA, May 1983.

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# CONCEPTS FOR MECHANICAL

# REMOVAL OF RESIN AND DEBRIS

# AND LOADING SHIPPING CONTAINERS

W. W. Jenkins
June, 1983

TABLE OF CONTENTS

## SUMMARY

This document describes a concept for removing the resin and debris from the Three Mile Island Unit 2 (TMI-2) Make-Up and Purification Demineralizers by methods other than sluicing the contents through the existing resin sluice lines. The concept uses a high velocity water stream to break up or agitate the resin bed in combination with a vacuum hose to remove the resin and debris. The concept is based on the assumption that the resin and debris are, or can be made, sluicable by impingement of a high velocity stream of water on the resin bed. A concept is also described for loading shipping containers to assure proper resin levels prior to shipment off-site.

## 1.0 INTRODUCTION

### 1.1 OBJECTIVE

The concept described herein provides an alternate approach to resin and debris removal which will be included in a forthcoming Planning Study. The Planning Study will evaluate a number of various concepts for possible implementation at TMI-2. In addition to the alternate approach to resin removal, a concept is described for loading SDS type shipping containers with resin and debris.

### 1.2 BACKGROUND

A conceptual design (Reference 1) of a resin and debris removal system was presented to EG&G/GPU personnel on March 30, 1983. The concept was based on the assumption that the resin beds in both make-up and purification demineralizers were in a sluicable form. It used the existing piping system to pump the demineralizer contents to a hold-up tank (resin transfer container) prior to shipment off-site for disposal. GPU personnel requested that WHC develop alternatives for removing resin and debris since:

1) Tests on resin samples obtained from both demineralizers have yet to confirm that the contents are sluicable in their present form.

2) GPU had a need for evaluating alternatives to assure that the concept selected for implementation is the most effective with regard to cost and schedule.

Based on the above, WHC proposed (Reference 2) that an alternate concept be developed for mechanical removal of resin and debris and that a concept be developed to assure proper resin levels in the shipping containers prior to shipment off-site.

## 1.3 SCOPE

This study identifies the functions and requirements for a resin removal system and describes a method for mechanical removal. The basic steps of the removal process are outlined and the physical interfaces with the existing TMI-2 equipment and plant are identified. Advantages and disadvantages of the mechanical removal approach are listed for evaluation and comparison with other concepts previously identified.

This study also presents a concept for loading shipping containers with resin. The need for a concept to determine when the relatively small shipping containers (SDS type liners) are filled to the proper level was identified at the March 30, 1983 meeting at TMI-2 and is one of a number of tasks identified in Reference 2.

## 1.4 CRITERIA

The following criteria are specified in the Resin and Debris Removal System Conceptual Design Report (Reference 1) and are applicable to the removal concepts discussed herein.

### 1.4.1 Removal System Functions

The resin and debris removal system shall provide the following specific functions:

A. Removal of essentially all radioactive solids and liquids from the Make-up and Purification Demineralizers, MU-K-1A and 1B.

B. Treatment of all liquid effluents to assure compatibility with on-site water processing systems (Submerged Demineralizer System and EPICOR II).

C. On-site handling of radioactive demineralizer contents consistent with normal TMI-2 practices.

D. Containerization of the radioactive demineralizer contents in a form suitable for use in a DOE research and development program.

E. Transportation of radioactive demineralizer contents to a DOE site using licensed or licensable containers and casks.

F. Flushing of lines after resin removal is complete.

### 1.4.2 Removal System Process Requirements

A. Existing TMI-2 systems and equipment shall be used to the maximum extent practical.

B. Selection of existing piping and routing of new piping shall minimize personnel exposure consistent with ALARA considerations in place at TMI-2. Maximum use should be made of existing architectural features.

C. Operational process selection shall result in minimizing personnel exposure consistent with ALARA considerations in place at TMI-2.

D. The resin and debris removal system shall perform its required functions only during normal plant operating and clean-up conditions.

E. The resin and debris removal system is a temporary system and shall be removed when its required functions have been performed. Any modifications to the existing TMI-2 systems shall include provisions for returning those systems to their original configuration. Radiation levels in the permanent piping shall be left in a condition acceptable for the original design usage.

F. Materials used in the removal system shall be compatible with the conveyed and contained internal fluids and with the surrounding environment including the anticipated radiological dosage.

G. Operation of the resin and debris removal process shall be independent of the handling, storage and transportation of the waste packages.

H. TMI-2 plant demineralized water, processed water, reactor coolant grade water and nitrogen sources may be utilized provided that precautions exist to preclude backflow into these systems.

1.4.3 Codes and Standards

A. USNRC Regulatory Guide 1.143, Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.

B. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. ANSI B31.1 Power Piping Systems.

D. Title 49, Code of Federal Regulations, Part 173, Department of Transportation Hazardous Material Regulations.

E. NEC - National Electric Code.

F. NEMA - National Electrical Manufacturers' Association.

G. ASME/ANSI NQA-1, Quality Assurance requirements for Nuclear Power Plants.

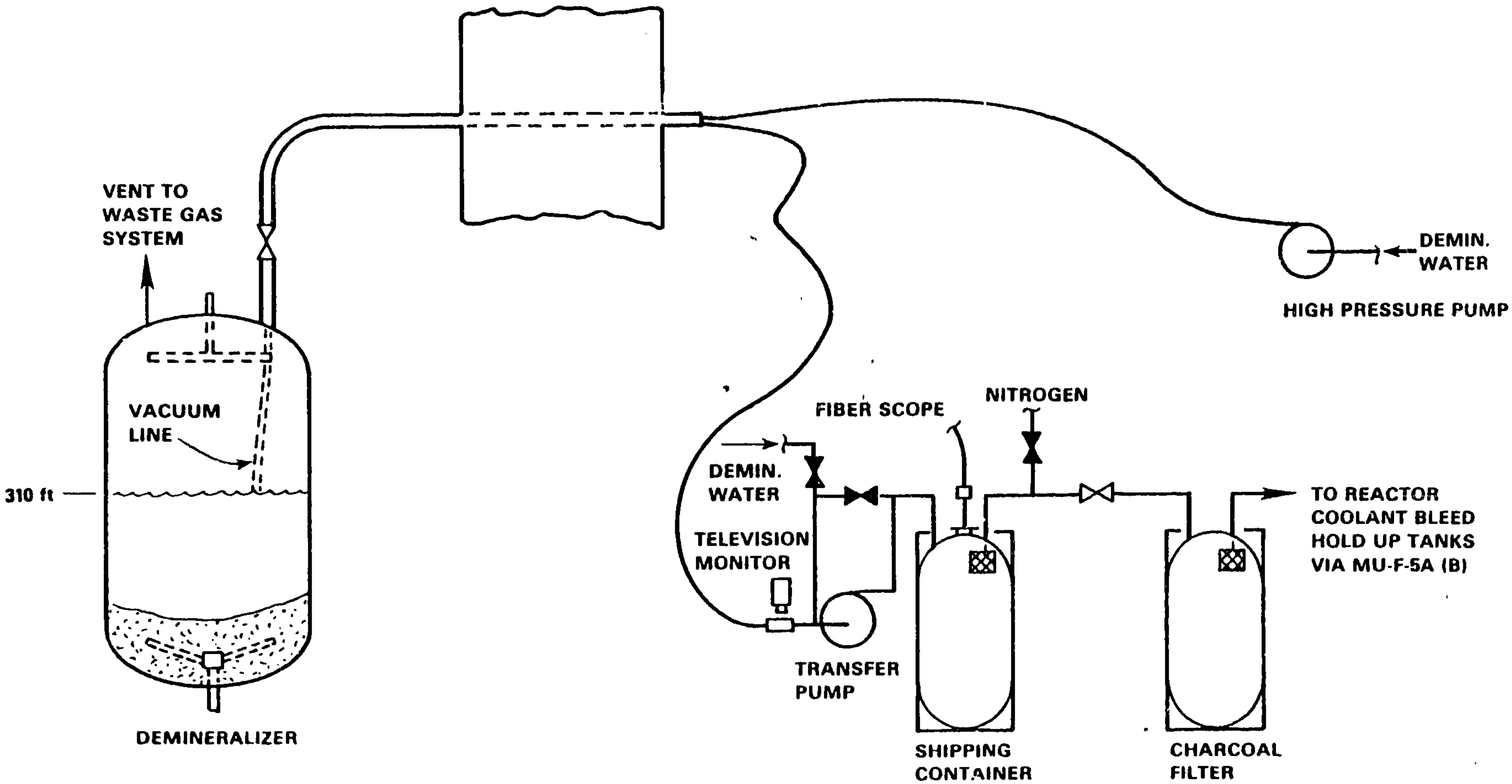
## 1.5 APPROACH

The mechanical removal system provides for the removal of complex organic compounds from the demineralizer effluent prior to sending the effluent to the SDS and EPICOR-II water treatment systems. The mechanical removal system also provides for elution of the resin bed with processed water to remove $^{137}Cs$ prior to transferring the resin and debris to the shipping containers. A method for loading the shipping containers with resin is described. Final steps in the process are a flushing operation with a high pressure water lance and a rinsing operation with demineralized water to wash residual resin and debris from the interior surfaces of the demineralizer vessel. Individual steps of the process are outlined below:

Step 1. Remove Complex Compounds and Cesium (See Figure 1)

| Procedure | Comments |
|---|---|
| • Insert vacuum line to 310' elevation. | Insert through resin fill line. |
| • Start transfer pump. Add demineralized water through normal inlet line. Fill to 310' elevation. Secure transfer pump. | Secure fill when water enters transfer pump. Vent demineralizer through existing vent to waste gas system. Assumes existing vents from demineralizers are operable. |
| • Sparge resin bed with nitrogen through normal outline line. | Vent demineralizer through existing vent to waste gas system. Sparging will initiate break-up of resin bed. |
| • Secure nitrogen sparge. Add approximately 100 gallons of demineralized water through normal outline line. | Will require water meter installation in demineralized water supply line. Chemical injection capability in water supply line may also be required for elution of cesium from resin bed. Water level now at approximately 311' elevation. |
| • When resin and debris settle, pump down to 310' elevation using transfer pump. Pump through shipping container and charcoal filter to reactor coolant bleed hold-up tanks. | Assumes that one pass through charcoal filter will remove sufficient complex organic compounds to be compatible with SDS and EPICOR II. Flow rate is less than 5 gpm. |
| • Repeat last two steps until sampling or radiation monitors indicate no further reduction in gamma radiation from the demineralizer. | |

# 1. REMOVE COMPLEX COMPOUNDS AND CESIUM




HEDL 8305-098.1

FIGURE 1

Step 2. Remove Resin and Debris (See Figure 2)

| Procedure | Comments |
|---|---|
| · Lower vacuum line to surface of resin bed. | |
| · Insert lance into resin bed. | Lance is high pressure flexible hose containing nozzle with spray pattern at right angles to lance (provides horizontal circular spray pattern). |
| · Sparge with nitrogen through normal outline line. | Vent demineralizers through existing vents to waste gas system. |
| · Start high pressure pump. | |
| · Start transfer pump. | Method of controlling or monitoring water level in demineralizer will be required to prevent overfilling demineralizer. |
| · Collect resin in shipping container. | Shipping container has 10 micron back flushable metallic filters to retain resin. Water (and small fuel fines) that exit the shipping container enters charcoal filter. Charcoal filter has one micron retention filter to retain 80-100 mesh charcoal fines. |

Step 2. Remove Resin and Debris (See Figure 2) (continued)

| Procedure | Comments |
| --- | --- |
| • Continue recirculating to collect resin. Lower lance as required to break up and agitate resin bed. | Monitor resin and debris collection progress by observing TV monitor and radiation detectors on demineralizer and shipping container. TV camera is set up to observe influent to transfer pump. Instrumentation is required to monitor $\Delta p$ across shipping container and charcoal filter and to monitor flow through the system. |
| • When inlet flow to transfer pump stops, secure transfer pump and high pressure pump. | Check resin level in shipping container using fiberscope. If container is not full, backflush filter(s). If container is full, proceed to Step 3. |

## 2. REMOVE RESIN AND DEBRIS

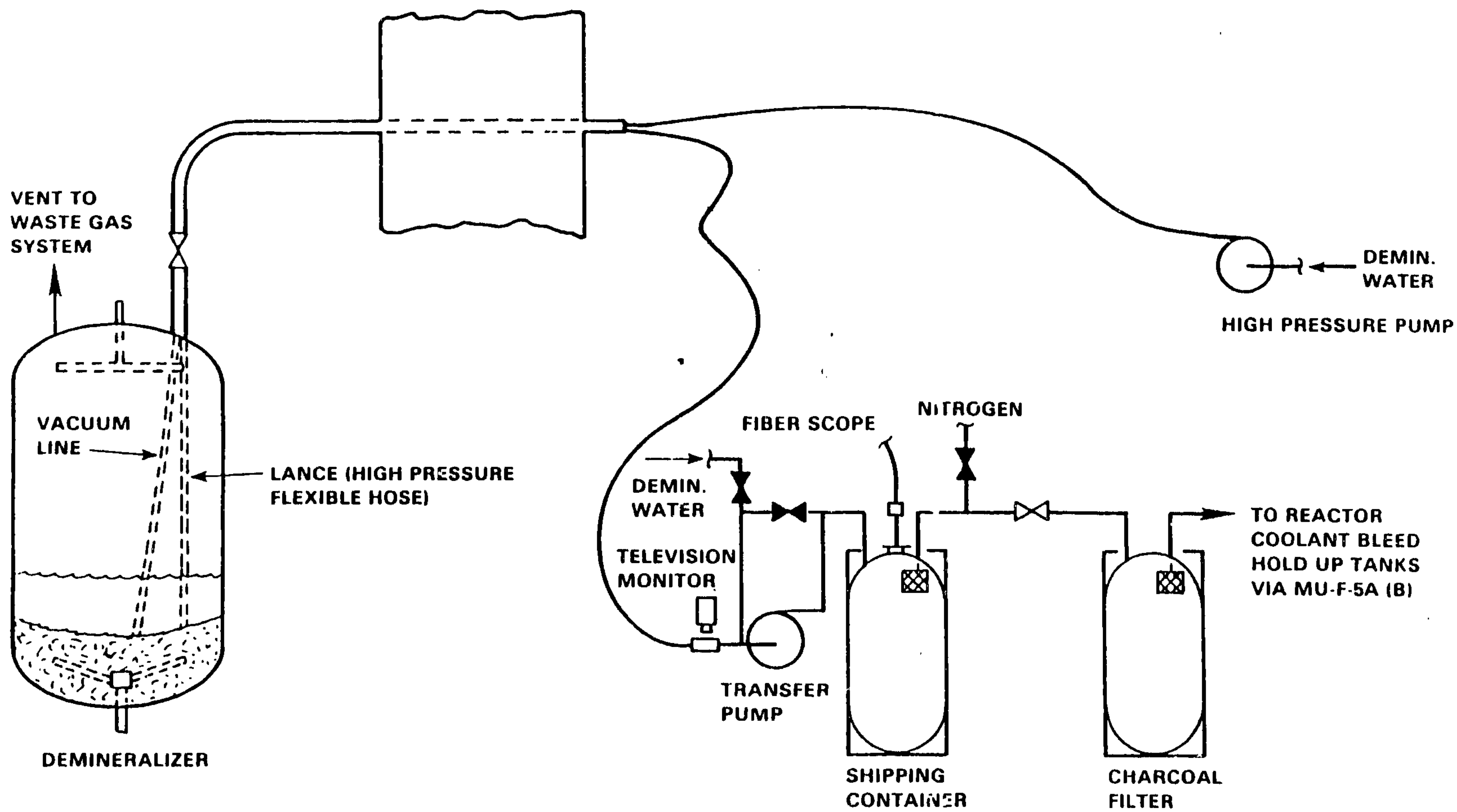



FIGURE 2

HEDL 8305-098.2

Step 3. Change-Out Shipping Container (See Figure 3)

| Procedure | Comments |
|---|---|
| · Secure valve between shipping container and charcoal filter. | |
| · Backflush shipping container with nitrogen. | Open by-pass line around transfer pump. Nitrogen will clear lines and connections at top of container. Resin and debris in top few inches of shipping container will be blown back into demineralizer. |
| · Observe final resin level with fiberscope. | Shipping container is equipped with plug-in connection for fiberscope. |
| · Disconnect piping (flex hose) to shipping container. | Remotely actuated tools required to reduce personnel exposure. |
| Install new (empty) container and continue with resin and debris removal. | Additional facilities will be required to dewater, degas and prepare container for storage and shipment. |

## 3. CHANGE OUT SHIPPING CONTAINER

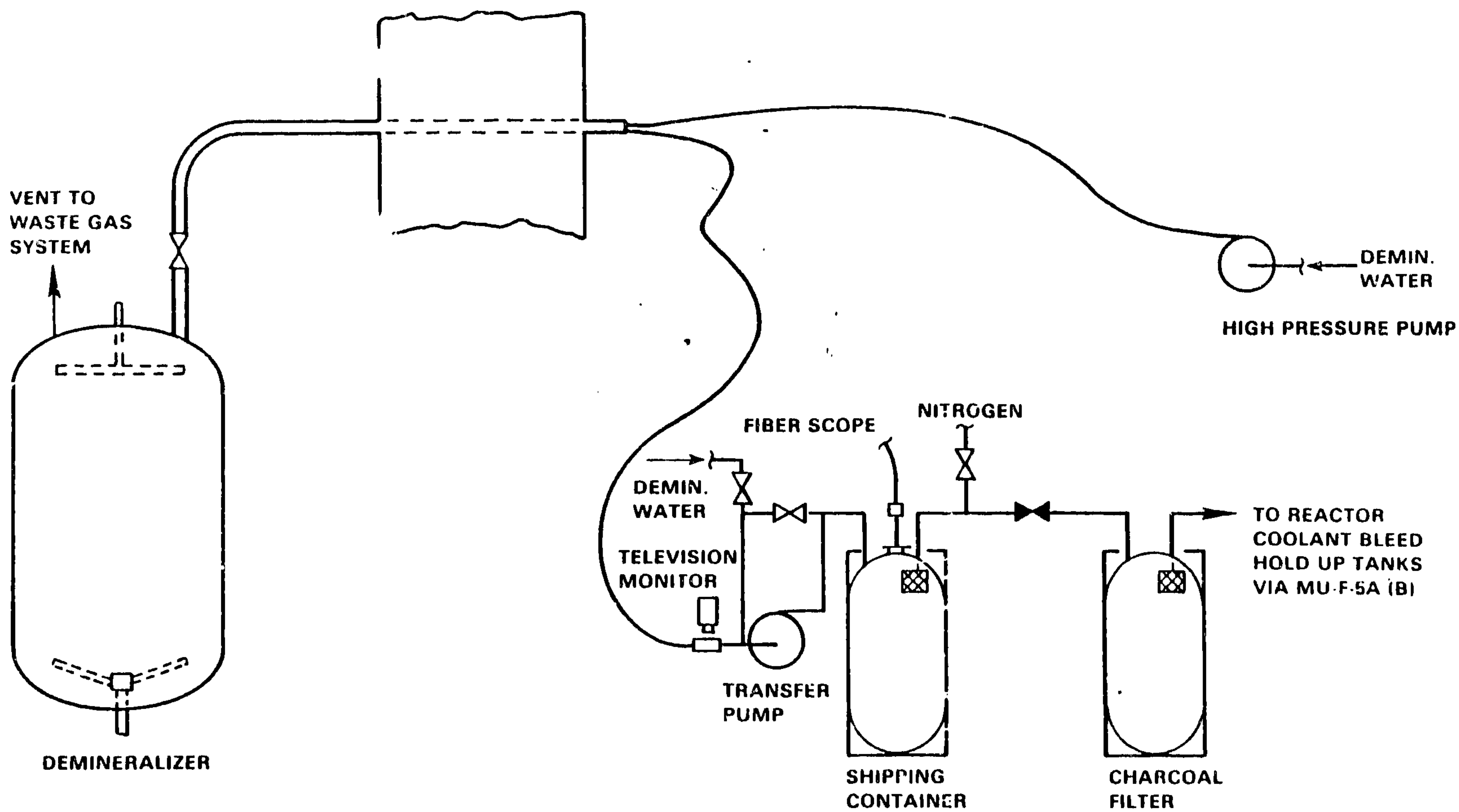



FIGURE 3

HEDL 8305-093.3

Step 4. Final Flush of Demineralizer (See Figure 4)

| Procedure | Comments |
|---|---|
| • Insert vacuum line to bottom of demineralizer. Start transfer pump. | |
| • Start high pressure pump. | |
| • Wash down walls of demineralizer by raising and lowering lance. | Lance can be operated by hand since washing is done with non-radioactive water. |
| • Add demineralized water through normal outlet. Fill to approximately 312' elevation. | Level can be determined by raising vacuum line to 312' elevation and starting transfer pump and by water meter in demineralizer water supply line. |
| • Insert vacuum line to bottom of demineralizer and pump down demineralizer. Repeat flushing steps as required to clean up demineralizer interior surfaces. | |

# 4. FINAL FLUSH OF DEMINERALIZER

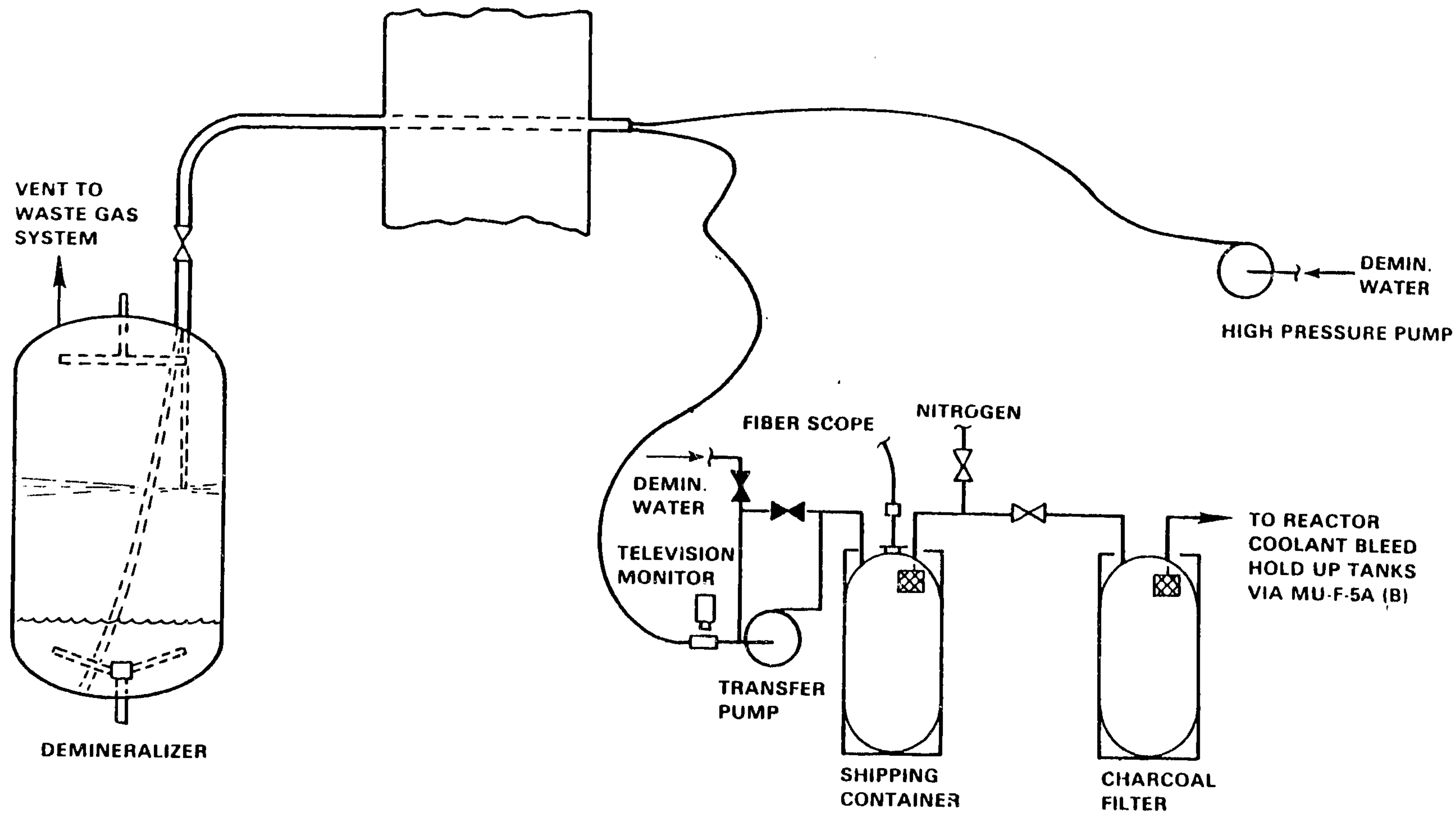



FIGURE 4

HEDL 8305-098.4

## 2.0 ADVANTAGES AND DISADVANTAGES

The advantages and disadvantages of the mechanical removal concept are listed below.

### Advantages

1. Equipment (including temporary piping) required is minimal; therefore, cost is relatively low.

2. Equipment is small in size; therefore, all items could be located in the Hayes gas analyzer room (without removing knock out walls and instrumentation racks). The ability to place all process equipment in the Hayes gas analyzer room eliminates possible interference with other clean-up operations at TMI-2.

3. Tie-in points to existing piping system are readily accessible.

### Disadvantages

1. System operators cannot see the resin bed or the position of the lance; therefore, the process will be very time consuming (hit and miss) with regard to resin and debris removal. Note: A Fiberscope will be required to inspect the interior of demineralizer to determine progress of clean-up operation.

2. Resin and debris cannot be removed from 3-inch diameter resin outlet line at bottom of demineralizer.

3. Water level or water volume inventory system must be employed to assure that demineralizer is not overfilled with resultant spill of contaminated water out the resin fill line.

4. Requires use of existing vent lines from top of demineralizers to vent cover gas. These valves in the vent lines may not be operable.

Disadvantages (continued)

5. Shipping container will contain TRU concentrations that will prevent disposal at commercially operated disposal sites; therefore, disposal costs will be relatively high.

## 3.0 EVALUATION AND RECOMMENDATION

The process described is mechanical in the sense that a high velocity water stream is used to erode an otherwise unsluicable resin bed. The process is based on the assumption that the resin can be broken up by the water stream and that once broken up, the resin and debris are sluicable. The process may be better described as a hydro-mechanical process. In any event, it provides an alternative to removal of resin and debris via the normal resin sluice line which was the required task identified in Reference 2.

Considering the complexities of equipment and the development effort that would be required for a completely mechanical system for removing the demineralizer contents, the hydro-mechanical concept described herein appears reasonable. It is recommended that prior to developing a completely mechanical system such as robotic arms, other techniques such as chemical dissolution (reference 1) be re-evaluated for possible implementation at TMI-2.

## 4.0 REFERENCES

1. MK Mahaffey, EJ Renkey, WW Jenkins, LM Martinson, and RD Hensyel, "Resin and Debris Removal System Conceptual Design," HEDL-7335, Draft Report.

2. Letter, EP Vodney, Controller, WHC to JJ Sutey, Director, Budget Division, DOE-RL, "FY-83 Budget Revision for TMI-2 Demineralizer Resin Removal," 8351230 dated April 11, 1983.

# TMI-2 RESIN REMOVAL

## CONCEPTS FOR USE OF SPENT RESIN STORAGE TANKS

CONTENTS

## SUMMARY

This study evaluates three options for removing resin and debris from the Makeup and Purification demineralizers. Each of these options incorporates a Spent Resin Storage tank into the resin and debris removal process system. The advantages and disadvantages of each option are listed for comparison along with the advantages and disadvantages of the resin and debris removal concept identified in HEDL document 7335 which does not use the Spent Resin Storage tanks.

# SECTION 1.0

## INTRODUCTION

### 1.1 OBJECTIVE

This study evaluates options for removing resin and debris by incorporating the Spent Resin Storage tank(s) in the overall process. These tanks, including the associated piping, resin transfer pump and instrumentation, are existing components that have been designed to accept and transfer spent resin (but not debris) from the demineralizers. The objective of this study is to identify the advantages and disadvantages of using this equipment to enable a comparison with other processes under consideration which do not use the Spent Resin Storage tanks.

### 1.2 BACKGROUND

Part of the cold leg coolant flow from the TMI-2 reactor is diverted to the purification/makeup system during normal reactor operation. The system was on line during the TMI-2 accident. After approximately 16 hours into the accident, the filters upstream of the makeup and purification demineralizers became blocked and were bypassed (Reference 1). Based on subsequent activities to characterize the demineralizers (References 2 and 3) it was determined that both demineralizers (MU-I-1A and MU-K-1B) contain highly radioactive resin and debris.

Based on resin scoping tests performed by Pacific Northwest Laboratory (Reference 4) Hanford Engineering Development Laboratory presented a concept for resin removal to EG&G and GPU Nuclear personnel that was based on the assumption that the resin in both demineralizers was sluicable. The concept did not make use of the existing Waste Disposal System for the following reasons:

(1) Transferring the resin and debris from the demineralizers to the Spent Resin Storage tanks did not accomplish the overall objective of removing the abnormally contaminated waste from TMI. It also resulted in additional components becoming contaminated to high levels.

(2) The irradiated resin may provide information that could benefit the industry at a future date; therefore, it was considered that a certain quantity should be made available for that purpose, and

(3) The irradiated resin, in water, will release complex organic compounds which may not be compatible with the SDS and EPICOR II water treatment systems. If the water used to sluice the resin and debris to the Spent Resin Storage tanks entered the SDS and EPICOR II systems, it may contaminate the processed water at TMI-2.

Based on the discussions following the HEDL presentation (Reference 5) it was agreed that HEDL would provide additional inputs into GPU's technical planning for resin removal. One of these inputs was to evaluate the use of existing plant piping, including the Spent Resin Storage Tanks, to the maximum extent practicable.

## 1.3 SCOPE

Three options are identified in this study to maximize the use of existing plant piping and systems. Two of these options use the Spent Resin Storage tank and the associated piping and components in their entirety. The third option uses the Spent Resin Storage tank as a temporary collection and holding tank for contaminated sluice water only. The third option has the potential of completely by-passing the Waste Disposal System (WDS) if it can be demonstrated that complex organic compounds can be removed from the sluice water by a single pass through a charcoal filter (or resin bed) designed specifically for removal of these complex compounds. Each option is evaluated by comparing the advantages and disadvantages including the advantages and disadvantages of the removal concept discussed in the conceptual design report (Reference 4).

## 1.4 CRITERIA

The following criteria are specified in the Resin and Debris Removal System Conceptual Design Report (Reference 4) and are applicable to the process options that include the Waste Disposal System:

### 1.4.1 Removal System Functions

The resin and debris removal system shall provide the following specific functions:

A. Removal of essentially all radioactive solids and liquids from the Makeup and Purification Demineralizers, MU-K-1A and 1B.

B. Treatment of all liquid effluents to assure compatibility with onsite water processing systems (Submerged Demineralizer System and EPICOR II)

C. Onsite handling of radioactive demineralizer contents consistent with normal TMI-2 practices.

D. Containerization of the radioactive demineralizer contents in a form suitable for use in a DOE research and development program.

E. Transportation of radioactive demineralizer contents to a DOE site using licensed or licensable containers and casks.

F. Flushing of lines after resin removal is complete.

### 1.4.2 Removal System Process Requirements

A. Existing TMI-2 systems and equipment shall be used to the maximum extent practical.

B. Selection of existing piping and routing of new piping shall minimize personnel exposure consistant with ALARA considerations in place at TMI-2. Maximum use should be made of existing architectural features.

C. Operational process selection shall result in minimizing personnel exposure consistent with ALARA considerations in place at TMI-2.

D. The resin and debris removal system shall perform its required functions only during normal plant operating and clean-up conditions.

E. The resin and debris removal system is a temporary system and shall be removed when its required functions have been performed. Any modifications to the existing TMI-2 systems shall include provisions for returning those systems to their original configuration. Radiation levels in the permanent piping shall be left in a condition acceptable for the original design usage.

F. Materials used in the removal system shall be compatible with the conveyed and contained internal fluids and with the surrounding environment including the anticipated radiological dosage.

G. Operation of the resin and debris removal process shall be independent of the handling, storage and transportation of the waste packages.

H. TMI-2 plant demineralized water, processed water, reactor coolant grade water and nitrogen sources may be utilized provided that precautions exist to preclude backflow into these systems.

1.4.3 Codes and Standards

A. USNRC Regulatory Guide 1.143, Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.

B. ASME Boiler and Pressure Vessel Code, Section VIII Division 1.

C. ANSI B31.1 Power Piping Systems.

D. Title 49, Code of Federal Regulations, Part 173, Department of Transportation Hazardous Material Regulations.

E. NEC - National Electric Code.

F. NEMA - National Electrical Manufacturers' Association.

G. ASME/ANSI NQA-1, Quality Assurance Requirements for Nuclear Power Plants.

## 1.5 APPROACH

The three approaches to resin and debris removal which use the Spent Resin Storage Tank (Waste Disposal System - WDS) are outlined below. The resin and debris removal concept outlined in the Resin and Debris Removal System Conceptual Report (Reference 4) is included for information. The advantages and disadvantages of each approach are listed in Table I.

### 1.5.1 <u>Approach A - Use of Existing System with Hittman Type Shipping Containers - See Figure 1</u>

Step 1. Sluice to Spent Resin Storage Tank

- Add nitrogen and demineralized water to demineralizer through the normal outlet line to generate a resin slurry. (Open valves MU-V292, MU-V114 and MU-V291).

- Add demineralized water to demineralizer through sluice line using existing connection to sluice line header. (Open valves WDS-V136, MU-V108 and MU-V238). This will unpack resin in resin sluice line upstream of valves MU-V108 and MU-V238.

- Monitor pressure increase in demineralizer MU-K-1A or MU-K-1B (remove resin and debris from one demineralizer at a time). Do not vent gas (nitrogen blanket) from demineralizer.

- When pressure in demineralizer reaches 75 psig, secure demineralized water to sluice line (shut WDS-V136) and open inlet valve to Spent Resin Storage Tank WDS-T-1B (open WDS-V60B). Attempt to maintain 75 psig in the demineralizer by throttling nitrogen and demineralizer water valves (MU-V114 and MU-V292). If pressure increases, secure MU-V114 first to assure continuous supply of sluice water. If pressure goes to zero, the contents have been transferred to the Spent Resin Storage Tank. If pressure remains constant with MU-V114 and MU-V292 shut and the sluice line valves open, the sluice line is plugged. Estimated quantity of demineralized water required to sluice resin and debris from each demineralizer is 1200 gallons.

Step 2. Add demineralized water and nitrogen to generate slurry in Spent Resin Storage Tank.

- Generate slurry by adding demineralized water (open WDS-V124B) and adding nitrogen (open WDS-V88). Vent gas from Spent Resin Storage tank to Waste Gas System through WDG-V100B. Add demineralized water at rate of 50 gpm for 20 minutes (1000 gallons). Spent Resin Storage tank will now contain approximately 2200 gallons of water (capacity is 3861 gallons). Continue to sparge with nitrogen to maintain slurry.

Step 3. Pump slurry to concreting system (shipping container) through existing piping intended for this purpose.

- Assume that concreting system can be placed on 305' elevation of Auxiliary and Fuel Handling Building near intersection of column lines A65 and AT.

- Start and stop the Spent Resin Transfer Pump (WDS-P-1) as required to limit the amount of TRU in each shipping container to less than 100 nano Ci/gram of waste and/or less than the upper total curie limit of the shipping container. This may require a number of containers.

  Note: If total curie limit per container is limiting, the $^{137}Cs$ may be eluted from the resin by adding a chemical injection system just upstream of the shipping container.

- If resin is required for resin evaluation program, divert required samples to special containers provided for this purpose.

Step 4. Dewater the shipping container.

- Dewater by using Booster Pump downstream of shipping container. Pump through a charcoal filter to remove complex organic compounds and fuel fines down to 1 micron before returning effluent to Spent Resin Storage Tank. Return effluent via existing 2 inch return line (open WDS-V125).

  Note: If it can be demonstrated that the charcoal filter can remove sufficient complex organic compounds in one pass through the filter, the effluent can be diverted to SDS (via the Reactor Coolant Bleed Hold Up Tank).

Step 5. Remove complex organic compounds from sluice water.

- When all resin and debris have been deposited in shipping containers, recirculate sluice water through the charcoal filter to remove complex organic compounds and fuel fines down to 1 micron. Sample to determine when sufficient complex compounds have been removed to allow transferring to SDS (via Reactor Coolant Bleed Hold Up Tank). (See Note under Step 4 above.)

Step 6. Transfer sluice water to SDS.

- Use the Spent Resin Transfer Pump (WDS-P-1) to pump the sluice water from the Spent Resin Storage Tank to SDS (via Reactor Coolant Bleed Hold Up Tank).

  Note: This will require a temporary shielded line between the process equipment and the Reactor Coolant Bleed Hold Up Tank.

Step 7. Flush systems with demineralized water.

- Add demineralized water to demineralizer for final flush. Assume approximately 2 volumes (1300 gallons).

- Add demineralized water to Spent Resin Storage Tank for final flush. Assume approximately two volumes (7600 gallons).

### 1.5.2 Approach B - Use of Existing System with SDS Type Shipping Containers - See Figure 2

Step 1. Sluice to Spent Resin Storage Tank (same as 1.5.1 Step 1).

Step 2. Add demineralized water and nitrogen to generate slurry in Spent Resin Storage Tank (same as 1.5.1 Step 2).

Step 3. Pump slurry to shipping containers through existing piping intended for this purpose.

- Assume shipping containers can be placed on 305' elevation of Auxiliary and Fuel Handling building near intersection of column lines A65 and AT.

- Start and stop the Spent Resin Transfer Pump (WDS-P-1) as required to prevent overfilling the 80 gallon shipping containers. Change out containers as required. Containers include five micron filter as retention element to retain resin and debris. Slurry is pumped through WDS-V58, V20, V142 and V-79.

Step 4. Dewater shipping container (same as 1.5.1 Step 4).

Step 5. Remove complex organic compounds from sluice water (same as 1.5.1 Step 5).

Step 6. Transfer sluice water to SDS (same as 1.5.1 Step 6).

Step 7. Flush systems with demineralized water (same as 1.5.1 Step 7).

### 1.5.3 Approach C - Use of Existing System with Resin Shipping Container and Without Recirculation - See Figure 3

Step 1. Sluice to Resin Container.

- Add nitrogen and demineralized water to demineralizer through the normal outlet line to generate a resin slurry. (Open valves MU-V292, MU-V114 and MU-V291.)

- Add demineralized water to demineralizer through temporary valve V-5 and valves MU-V108/MU-V238. This will unpack resin in the sluice line upstream of valves MU-V108 and MU-V238.

- Monitor pressure increase in demineralizer. Do not vent gas (nitrogen blanket) from demineralizer.

- When pressure in demineralizer reaches 75 psig, secure demineralized water to sluice line (shut V-5) and open V-8 to sluice resin and debris to Resin Container. Attempt to maintain 75 psig in the demineralizer by throttling nitrogen and demineralized water valves (MU-V114 and MU-V292). If pressure increases, secure MU-V114 first to assure continuous supply of sluice water. If pressure goes to zero, the contents have been transferred to the Resin Container. If pressure remains constant with MU-V114 and MU-V292 shut and the sluice line valves open, the sluice line is plugged. Estimated quantity of demineralized water required to sluice resin and debris from each demineralizer is 1200 gallons.

Step 2. Dewater Resin Container.

- Resin Container contains built-in submersible pump enclosed in casing of 100 mesh screen. As resin and debris are sluiced to Resin Container, dewater the container by running submersible pump. Pump water through hydrocyclone. Hydrocyclone underflow deposits particles in Debris Container. Debris Container has 1 micron retention filter element in overflow outlet line. Outlet line returns to Resin Container. Hydrocyclone overflow will contain particles up to 4 microns. Overflow is passed through Charcoal Filter containing 1 micron filter element in outline. Water with particles less than 1 micron is piped to Spent Resin Storage tank through WDS-V125.

  Note: If sufficient complex compounds can be removed by one pass through the Charcoal Filter, the effluent can be sent directly to a Reactor Coolant Bleed Hold Up tank. (Spent Resin Storage tank can be bypassed.)

Step 3. Recirculate liquid in Spent Resin Storage tank to remove complex compounds.

- See Note under step 2 above.

- To recirculate, use Spent Resin Transfer Pump and pump into Charcoal Filter through V-3 (Shut V-4 and V-2). Recirculate through WDS-V125. Sample until liquid can be released to SDS via the Reactor Coolant Bleed Hold Up tank. Shut V-3 and open V-4. Rinse system with demineralized water.

Step 4. Transfer fuel and debris to Debris Container.

- Shut V-2 and open V-1. Run submersible pump and recirculate until all fuel fines and debris are deposited into Debris Container. Sparge Resin Container with nitrogen to agitate resin and debris as required to transfer debris through 100 mesh screen and into Debris Container via the hydrocyclone. Continue until gamma spectrometry indicates that TRU content in Resin Container is less than 100 nano Ci/gram.

Step 5. Ship Resin Container as high level waste.

- Dewater and degas as required. Ship with submerisble pump intact.

Step 6. Ship Debris Container and Charcoal Filter as TRU waste.

- Dewater and degas as required.

### 1.5.4 Approach D - Upflow Downflow Process With Recirculation - See Figure 4

Step 1. Remove complex organic compounds.

- Circulate at slow (5 gpm) flow rate in upward direction through demineralizer. Use Transfer Pump shown in Figure 4. Circulate through Charcoal Filter and enter demineralizer through resin sluice line. Exit top through resin fill line. Circulate through Resin Transfer Container and back into Transfer Pump. Sample liquid. Continue to circulate until sample indicates that sufficent complex organic compounds have been removed by the Charcoal Filter.

Step 2. Remove cesium.

- Continue to circulate per above. Inject chemicals using Chemical Injection pump to elute cesium from resin. With cesium in solution, bleed system to SDS via Reactor Coolant Bleed Hold Up tank. Add demineralized water or processed water to Surge Tank for makeup water to the system. Continue feed and bleed with chemical addition until radiation levels ($\gamma$) in demineralizer stop decreasing.

Step 3. Remove resin and debris by fast upflow.

- Secure Transfer Pump and start Recirculation Pump to recirculate at fast (120 gpm) flow rate in upward direction through demineralizer. Some resin and debris will overflow into the resin fill line (tests indicate approximately 700% expansion of resin bed). Resin and large (up to 150 micron) particles of debris that overflow will be collected in Resin Transfer Container which includes built-in 100 mesh (150 micron) screen to retain resin beads. Some debris (fuel) will settle to bottom of Resin Transfer Container. Some fuel fines and debris smaller than 150 microns will pass through the 100 mesh screen, through the Recirculating Pump and into the hydrocyclone. The hydrocyclone will remove all fuel particles larger than 4 microns and all resin fines larger than 70 microns and return them to the Resin Transfer Container. Fuel fines ranging up to 4 microns will be recirculated through the demineralizer. This process continues until radiation levels ($\gamma$) in the demineralizer cubicle stop decreasing which indicates that no additional resin is being transferred from the demineralizer. The remaining resin and debris must be removed by downflow (Step 4).

Step 4. Remove resin and debris by fast downflow.

- Secure Recirculating Pump and terminate "fast" upflow. Lower water level in 300 gallon Surge Tank by bleeding system (downstream of Charcoal Filter) to Reactor Coolant Bleed Hold Up tank. Inject demineralized water into bottom of demineralizer through normal outline line to create slurry of resin in demineralizer. In parallel with this step, initiate fast upflow to clear resin sluice line of resin and debris upstream of valves MU-V108 and MU-V-238. Secure upflow and injection of demineralized water when water level in Surge Tank approaches high level alarm point. Immediately initiate fast down flow by changing valve line-up and restarting Recirculating Pump. Continue fast downflow recirculation until all resin and debris have been sluiced from demineralizer.

Step 5. Resin and debris transfer to Shipping Container.

- Transfer resin and debris from Resin Transfer Container to Shipping Container by injecting nitrogen and demineralized water into bottom of Resin Transfer Container to generate resin slurry and pumping the slurry, using the Transfer Pump, to the Shipping Container. The Shipping Container has a 5 micron filter element installed internally as a retention element to retain resin and large debris while allowing the overflow to pass out the top of the container. The overflow from the Shipping Container is passed through the Charcoal Filter which removes (retains) particles larger than 1 micron. Effluent from the Charcoal Filter is directed to SDS via the Reactor Coolant Bleed Hold Up tank.

## SECTION 2.0

## ADVANTAGES AND DISADVANTAGES

The advantages and disadvantages of each option are listed in Table I. The table identifies the options that are associated with each advantage and disadvantage to enable a comparison, on a qualitative basis, of the various options under consideration.

TABLE 1

ADVANTAGES AND DISADVANTAGES

| | ADVANTAGES | APPROACH A | B | C | D | REMARKS |
|---|---|---|---|---|---|---|
| 1. | Eliminates recirculation through demineralizers with resultant savings in costs associated with installation and removal of temporary piping. | X | X | X | | Eliminates recirculation line. |
| 2. | All waste shipments of resin and debris will be non TRU material (except for charcoal filter) with resultant decrease in storage and disposal cost. | X | | | | Also see Item 6. |
| 3. | Tie-in points to existing systems are in place. No need to break into existing piping (with subsequent repair) to make connections with temporary process equipment. | X | X | | | |
| 4. | Man rem expended during installation of processing equipment and temporary piping is essentially zero. | X | X | | | |
| 5. | Process does not require surge tank, hydrocyclone, chemical injection equipment or high capacity recirculation pump. | X | X | | | Also see Item 7. |
| 6. | Waste shipments of resin (in Resin Container) will be non TRU with resultant decrease in storage/disposal cost. | | | X | | Process separates resin from TRU. Debris Container will contain TRU. See also Item 2. |
| 7. | Process does not require surge tank or chemical injection equipment. | | | X | | Also see Item 5. |
| 8. | Process has potential for complete by-passing of Spent Resin Storage Tank and associated piping and components of the Waste Disposal System providing the charcoal filter can remove sufficient complex organic compounds in a single pass through the filter. | | | X | | Alo see Item 17. |
| 9. | Fuel fines larger than 1 micron are not released to the Waste Disposal System. | | | X | | |

| | ADVANTAGES | APPROACH A | B | C | D | REMARKS |
|---|---|---|---|---|---|---|
| 10. | Does not require a "start and stop" procedure to transfer resin and debris to shipping containers. | | | X | | |
| 11. | Relatively small quantity of water becomes contaminated since water is not required for transferring resin and debris from Spent Resin Storage Tank to Shipping Container. | | | X | | |
| 12. | Only 1 major tie-in point to existing piping required (sluice line). | | | X | | Approach A & B requires none but approach D requires 2. |
| 13. | Eliminates sluicing operations from Spent Resin Storage Tank to Shipping Containers. | | | X | X | |
| 14. | Uses low cost commercial submersible pump since seal leakage when installed in resin container is not a concern. | | | X | | Feature could also be incorporated into approach D. |
| 15. | Provides for elution of $^{137}Cs$ and other soluble radioactive isotopes from resin prior to resin transfer operations. | | | | X | |
| 16. | Recirculation provides for sampling of liquid waste prior to discharging to SDS via the Reactor Coolant Bleed Hold Up Tanks. | | | | X | Prevents inadvertent contamination of other systems. |
| 17. | Does not contaminate Waste Disposal System. | | | | X | Also see Item 8. Only short segments of existing piping are subjected to contamination. These segments are free of deadlegs and with the exception of a few feet of resin fill piping, are located inside shielded enclosures. The few feet of resin fill piping that becomes contaminated can be flushed and manually cleaned subsequent to resin and debris removal operations. |

| | ADVANTAGES | APPROACH A | B | C | D | REMARKS |
|---|---|---|---|---|---|---|
| 18. | Only one Resin Transfer Container needed. | | | | X | Two will be required for Approach C. |
| 19. | All offsite shipments of resin and debris will be in identical containers. | | | | X | Will use modified SDS liners. |
| 20. | Results in least risk with regard to plugging sluice line with resin and debris. | | | | X | Some resin and debris is removed through resin fill line. |
| 21. | Provides for unplugging the normal inlet lines to the demineralizers and collection of the fuel and debris in these lines. | | | | X | Unplugging normal inlet lines will also assist in final system flush. |

TABLE 1

ADVANTAGES AND DISADVANTAGES

| | DISADVANTAGES | APPROACH A | B | C | D | REMARKS |
|---|---|---|---|---|---|---|
| 1. | Contaminates currently clean Waste Disposal System with fuel fines and high $^{137}Cs$ activity. | X | X | X | | Waste Disposal System contains numerous dead legs, feeder lines and instrument penetrations. May not be applicable to approach C, see Item 8 under Advantages. |
| 2. | Sluicability of debris not known. Results in greater risk of plugging sluice line and resin transfer lines with resin and debris. | X | X | X | | |
| 3. | Transferring resin and debris from Spent Resin Storage Tank to shipping container requires a "start and stop" process. | X | X | | X | Increases risk of plugging piping with resin and debris. |
| 4. | Does not provide for elution of $^{137}Cs$ from resin prior to resin transfer and handling. | X | X | X | | ALARA consideration. |
| 5. | Sluicing to and from Spent Resin Storage Tank generates larger quantities of contaminated water than a transfer process that uses recirculated water. | X | X | | | |
| 6. | Requires procurement and modification (primarily for shielding) of concreting system. | X | | | | |
| 7. | Does not provide for unplugging normal inlet lines to demineralizers (if plugged). | X | X | X | | |
| 8. | Requires special sampling containers to collect resin and debris for use in resin evaluation program. | X | | | | |

| | DISADVANTAGES | APPROACH A | B | C | D | REMARKS |
|---|---|---|---|---|---|---|
| 9. | Most, if not all, waste shipments of resin and debris including charcoal filters will be classified as TRU. | | X | | X | Results in increased storage/ disposal cost. |
| 10. | Requires development of system to determine level of resin and debris in shipping containers. | | X | | X | Proper level must be known prior to shipment. |
| 11. | Process requires special Resin Container with built in screen and submersible pump. Will probably need two of these (one for each demineralizer). Also needs hydrocyclone and special Debris Containers. | | | X | | Also see Item 15. |
| 12. | Requires a recirculation line with resultant increase in piping and shielding installation and removal cost. | | | | X | |
| 13. | Requires tie-in point in resin sluice line with resultant increase in piping and shielding installation and cost. | | | X | X | |
| 14. | Requires tie-in point in MU-F-5A or 5B filter housing with resultant increase in cost. | | | | X | |
| 15. | Process requires surge tank, Resin Transfer Container, chemical injection pump, transfer pump, recirculation pump and hydrocyclone. | | | | X | Also see Item 11. |
| 16. | Feed and bleed process to elute $^{137}Cs$ from resin will result in contaminating additional quantity of water which must be processed by the SDS. | | | | X | Currently estimated at 10,000 gallons. |
| 17. | Requires high (100 gpm) flow rate through 1 micron filter in charcoal filter which may plug up with debris. This may result in a plugged sluice line. | | | X | | |
| 18. | Resin container curie content may be too high to permit shipment in existing shielded casks. | | | X | | |

## SECTION 3.0

## EVALUATION AND RECOMMENDATIONS

An evaluation of the advantages and disadvantages associated with the three options that use, or potentially use, the Spent Resin Storage tanks indicates that the most significant items are the following:

ADVANTAGES

| Item No. | Item | Approach |
|---|---|---|
| 3. | Tie-in points in place | A & B. |
| 8. | Potential for bypassing Waste Disposal System | C |
| 10. | Does not require "start and stop" process to sluice resin and debris | C |
| 13. | Eliminates sluicing operations from Spent Resin Storage Tank | C |

DISADVANTAGES

| Item No. | Item | Approach |
|---|---|---|
| 13. | Requires tie-in point in resin sluice line. | C |

Based on the above, it is recommended that Approach C - "Use of Existing System with Resin Shipping Container and without Recirculation" be further evaluated as a concept for resin and debris removal that utilizes the Spent Resin Storge tanks.

The primary advantage of Approach C is in eliminating the disposal of highly radioactive resin and debris into the complex piping system of the Waste Disposal System. If it can be shown that the charcoal filter in the system is capable of removing sufficient complex organic compounds in a single pass through the filter, the Waste Disposal System can be bypassed entirely. If the charcoal filter cannot remove sufficient complex compounds in a single pass, the effluent must be recirculated through the Spent Resin Storage tank but the effluent will not contain resin or fuel fines larger than 1 micron which is considered to be the smallest size that can be removed from a practical standpoint.

It is also recommended that laboratory tests be initiated to determine the capability of charcoal (or special resin beds) to remove complex organic compounds in a single pass through the filter bed. These tests can use the available organic compounds from previous irradiation tests on the TMI-2 type resins and should provide data on filter loading capacities and required residence time of the complex organic compounds in the charcoal (or special resin) bed.

## SECTION 4.0

## REFERENCES


1. R. E. Mason, R. R. Hobbins, B. A. Cook and P. E. MacDonald, "Interim Report on the TMI-2 Purification Filter Examination," EGG-TMI-6181, Draft Report.

2. F. H. Ruddy, J. H. Roberts, R. Gold, C. C. Preston and J. A. Ulseth, "Solid State Track Recorder Neutron Dosimetry Measurements for Fuel Debris Assessment of TMI-2 Demineralizer-A," HEDL-SA-2834, December 1982.

3. J. P. McNeece, B. J. Kaiser, R. Gold and W. W. Jenkins, "Fuel Content of the Three Mile Island Unit 2 Makeup Demineralizer," HEDL-TC-2301, December 1982.

4. M. K. Mahaffey, E. J. Renkey, W. W. Jenkins, L. M. Martinson and R. D. Hensyel, "Resin and Debris Removal System Conceptual Design," HEDL-7335, Draft Report.

5. Letter, G. J. Quinn to C. Hitz et al, "Purification Demineralizer Resin Removal Program Review Meeting Minutes, March 30 and 31, 1983, Meeting Minutes - GJQ-13-83," dated April 8, 1983.

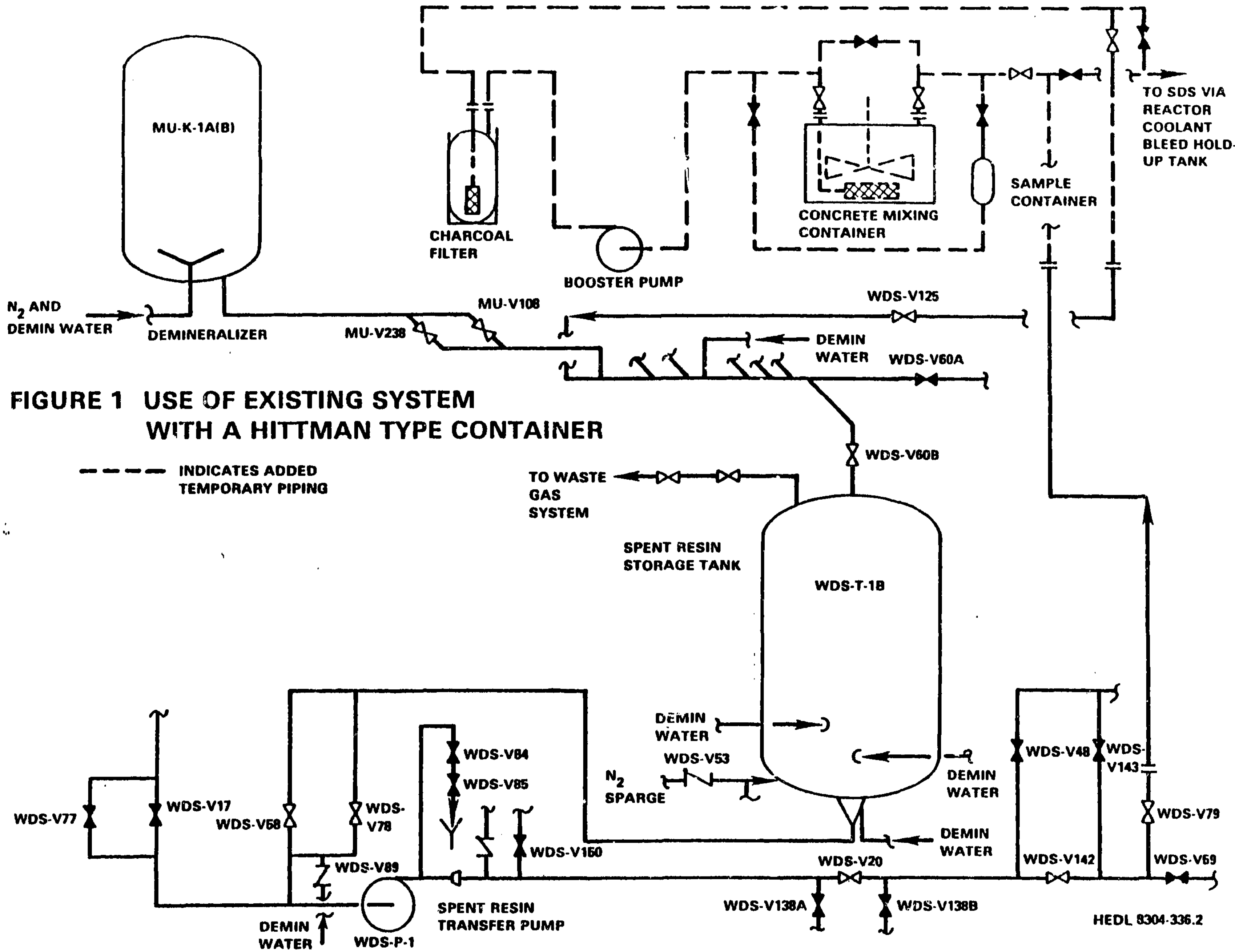



FIGURE 1. Use of Existing System with a Hittman Type Container.

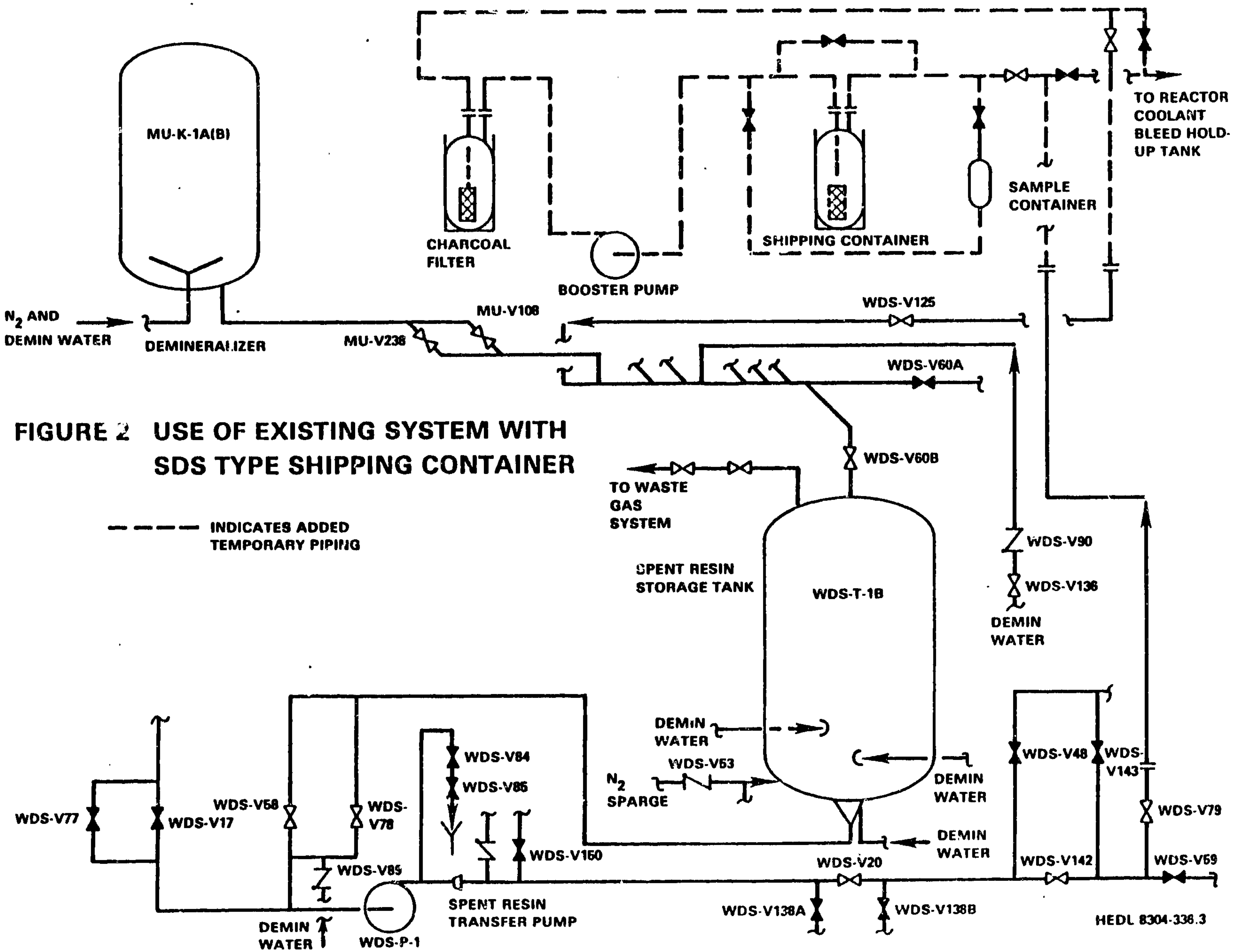



FIGURE 2. Use of Existing System with SDS Type Shipping Container.

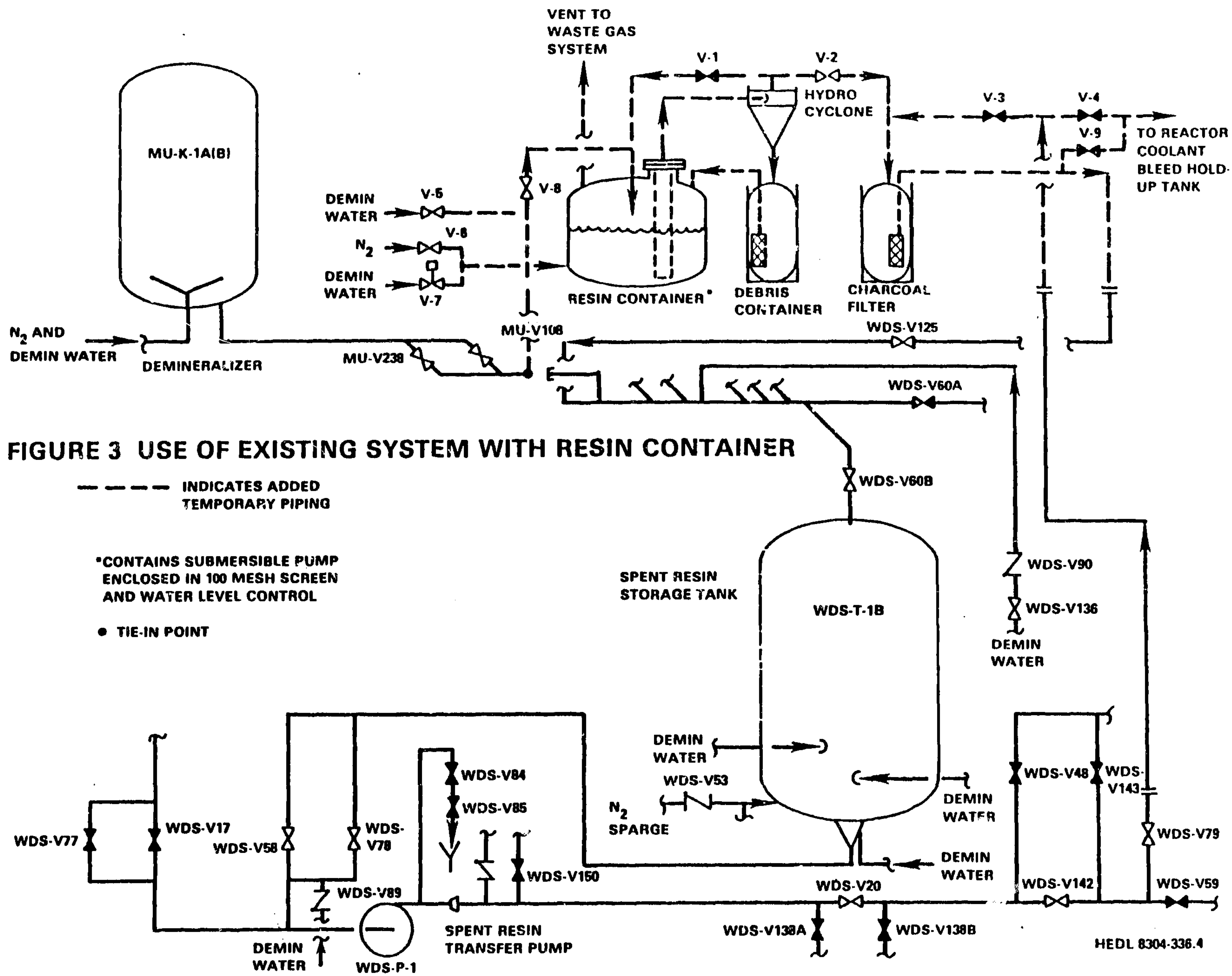



FIGURE 3. Use of Existing System with Resin Container.

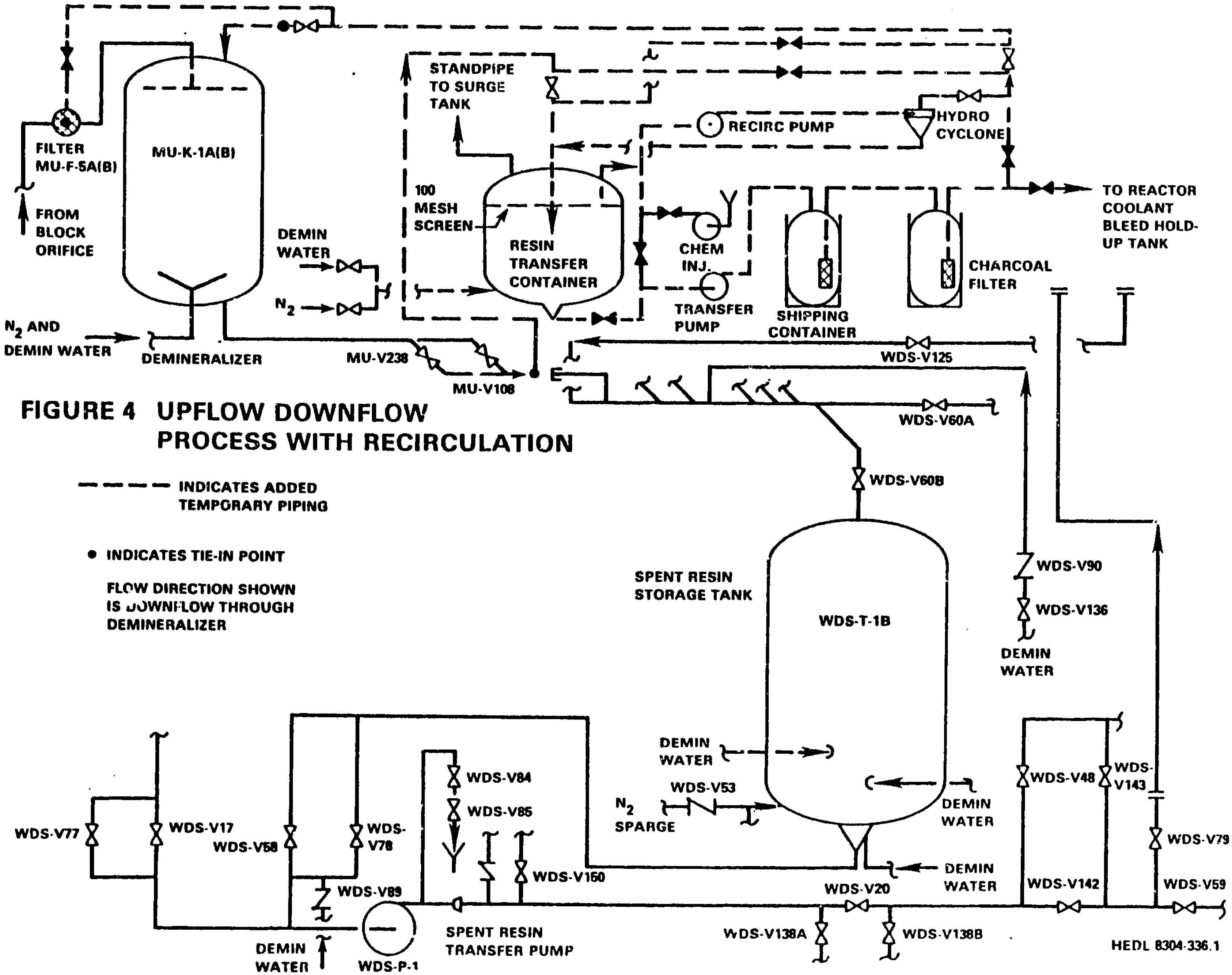



FIGURE 4. Upflow Downflow Process with Recirculation.

3.1.1.2 Advantages

a) The piping runs are short in length and are all, excluding the resin sluice line, centrally located in one room. This reduces the cost of piping and shielding and the radiation risk to the normal traffic on the 305' elevation.

b) All of the equipment is located on one elevation. Therefore, a forklift or rollers rather than the crane will be adequate for transferring the equipment.

c) The equipment is located in one room and out of the way of other TMI recovery activities.

3.1.1.4 Disadvantages

a) A knockout wall will have to be removed in order to install the skid and will remain out during the cleanup process for changing the charcoal filters and shipping containers.

b) Most of the instrument racks will have to be moved in order to fit the skid into place.

c) The gas analyzer is checked periodically by TMI personnel. This may be a safety problem where extra shielding may be required around the skid.

3.1.2 Alternate 2 - Use of Existing System with WDS Bypassed. See Figure 2

3.1.2.1 Description of the Layout

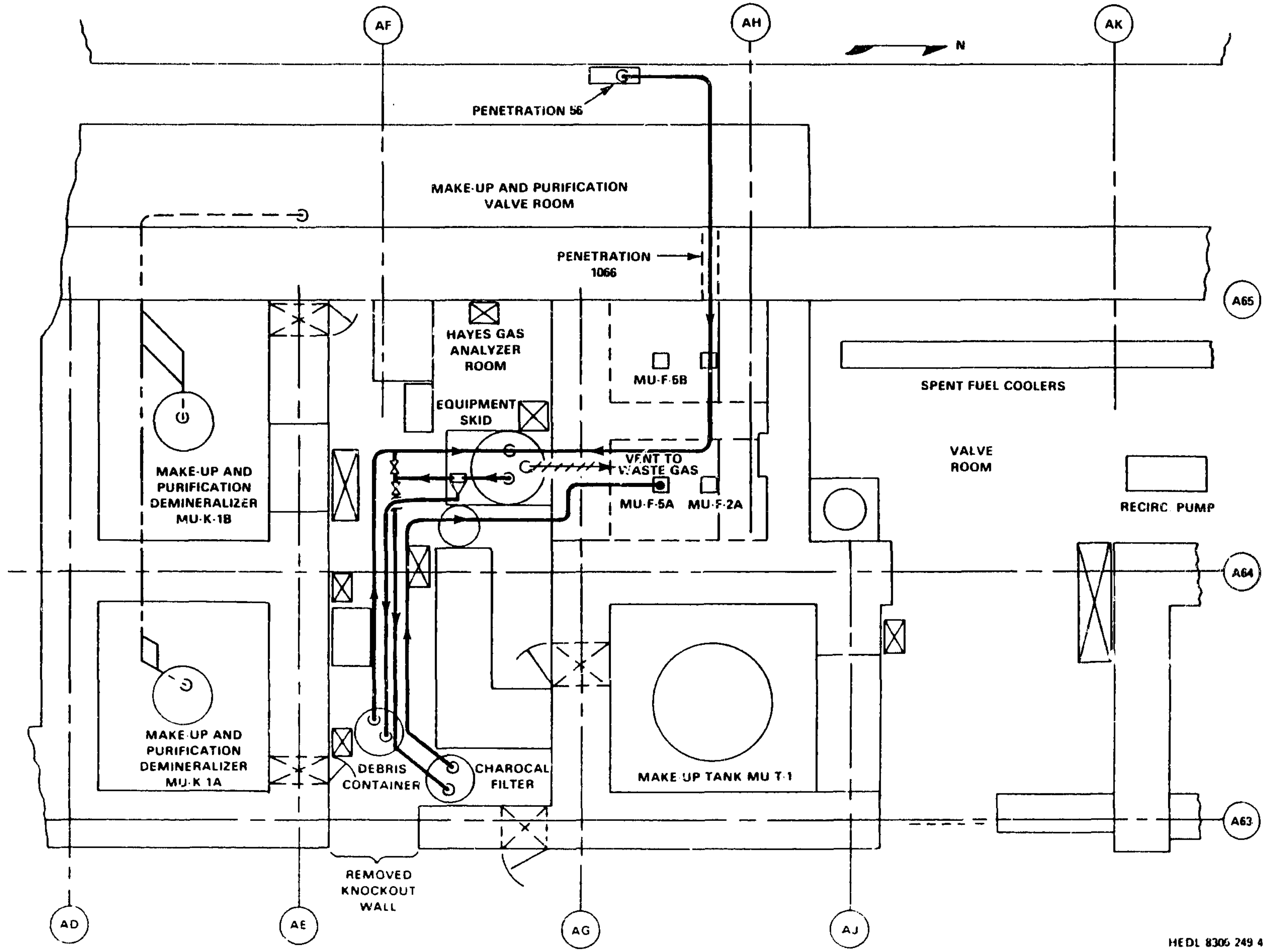
a) Penetrations Utilized

Same as Alternate 1.

FIGURE 2.

**EXISTING SYSTEM W/RESIN CONTAINER WDS BYPASSED**

## A. SKID ON 305 ft EL. HAYES GAS ROOM



b) Tie in Points

1) Break into the 2 inch resin sluice line, running along the ceiling of the 280'6" elevation valve and duct alley, between columns AF and AH. Tie in with new 2-1/2 inch process piping.

2) Tie in to the top of the Make up and Purification Filter housing MU-F-5A, with a special filter cover. This cover matches the original, but includes a section of 2-1/2 inch piping flanged at one end.

c) Skid Equipment

1) 300- gallon resin shipping container

2) Submerged pump

3) Hydrocyclone

d) Other Equipment Locations

1) Charcoal filter. This will be stationed between the removed knockout wall and the normal entrance at the east end of the Hayes Gas Analyzer Room.

2) Debris container. This will be located next to the charcoal filter but further into the room to allow access to the filter.

e) Piping Runs

1) A 2-1/2 inch line will run from the resin sluice tie in point, through both penetrations into the Hayes Gas Room and over to the skid.

2) A line runs between the skid and the debris container and then to the charcoal filter.

3) A return line from the charcoal filter will run to the skid or into Makeup Filter, MU-F-5A.

3.1.2.2 Assumptions

Same as Alternate 1.

3.1.2.3 Advantages

All of those in Alternate 1, plus:

d) Since all of the resin is sluiced into one shipping container, there is no transfer process to SDS liner type shipping containers. This also reduces the amount of equipment needed on the skid.

3.1.2.4 Disadvantages

Same as Alternate 1.

3.1.3 Alternate 3 - Use of Existing System WDS not Bypassed. See Figure 3

3.1.3.1 Description of the Layout

a) Penetrations Utilized

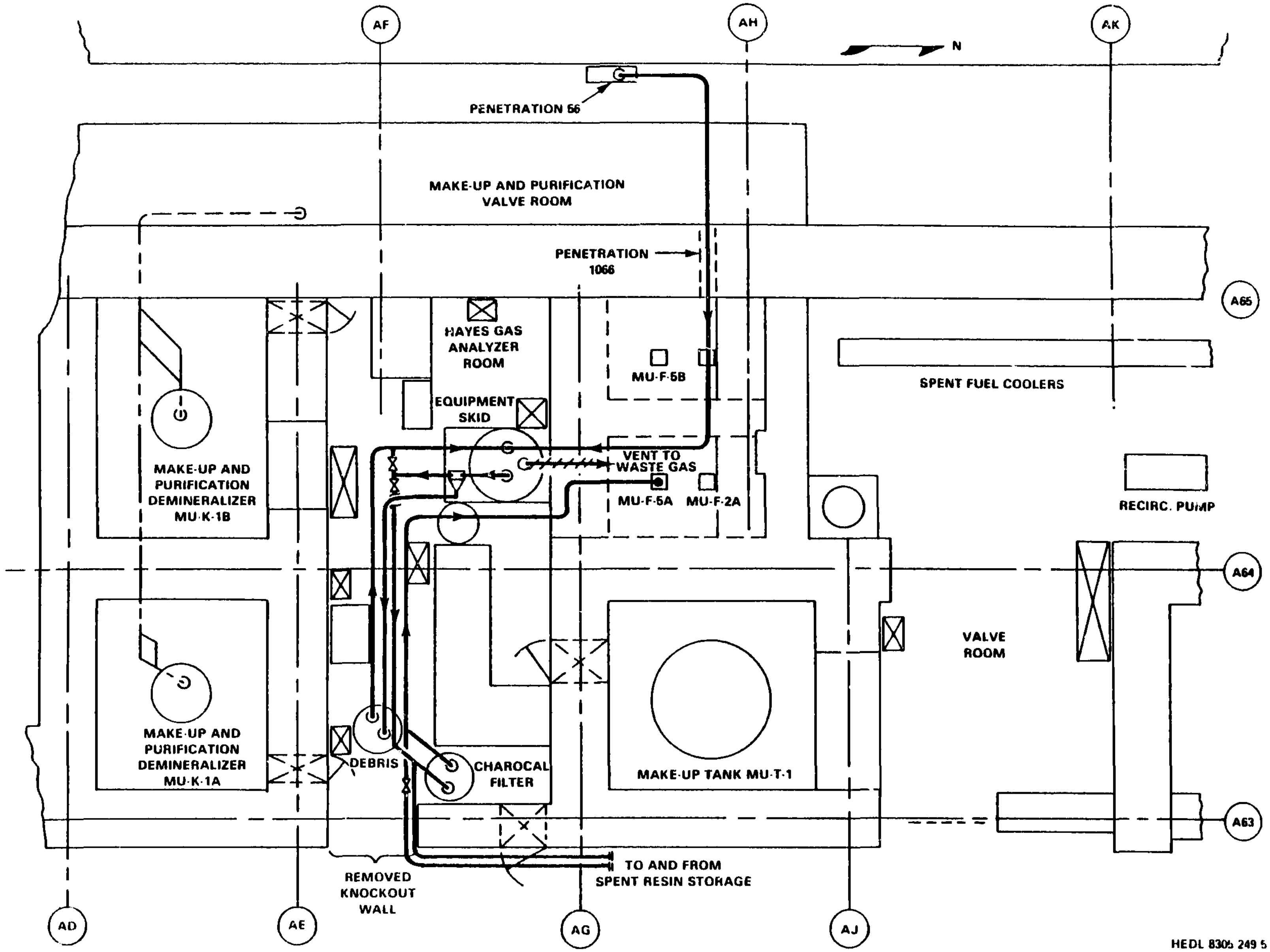
Same as Alternate 1.

b) Tie In Points

FIGURE 3.

EXISTING SYSTEM W/RESIN CONTAINER WDS NOT BYPASSED

## A. SKID ON 305 ft EL. HAYES GAS ROOM

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All of those in Alternate 2 plus:

3) Tie into the flanged end of the resin transfer line out of the Spent Resin Storage tank. This end is located in the Concentrated Liquid Waste Pump Room on the 305' elevation. Or break into the resin transfer line running along the ceiling of the 280'6" elevation valve and duct alley.

4) Tie into the flanged end of the dewatering line that runs back to the Spent Resin Storage tank. This is located next to the resin transfer flange. Or, this line runs adjacent to the resin transfer line in the valve and duct alley for an equivalent tie in to No. 3 above.

c) Skid Equipment

Same as Alternate 2.

d) Other Equipment Locations

Same as Alternate 2.

e) Piping Runs

All of those in Alternate 2 plus:

4) A 2-1/2 inch line runs from the charcoal filter, out through the corridor and into the Concentrated Liquid Waste Pump, WDS-P-2, Room to the flanged end of the dewatering line. Or run a line along side of the resin sluice line out both penetrations and along the 280'6" elevation valve alley ceiling to the dewatering tie in point.

5) A second 2-1/2 inch line will run beside the piping in No. 4 above to the resin transfer tie in point in both options.

3.1.2.1 Assumptions

All of those in Alternate 1 plus:

e) The connections to the spent resin storage tank in the 280'6" valve alley will be a possible method of tieing in.

3.1.3.3 Advantages

Same as Alternate 2.

3.1.3.4 Disadvantages

All of those in Alternate 1 plus:

d) The lines to and from the spent resin storage tank are quite long, thus increasing cost and shielding.

e) If the first method of tieing into the flanged ends for the spent resin tank recirculation lines is used, the piping will run through an area of normally heavy traffic.

f) If the second method is used, this means cutting or hot trapping into the run of piping in the 280'6" valve alley ceiling.

3.2 APPROACH B - Skid on the 280'6" Elevation

The skid will be stationed just east of the R.C. Make up and Purification Pump Room, MU-P-1A, between columns AN and AL.

3.2.1 Alternate 1 - Upflow - Downflow Recirculation, See Figure 4.

3.2.1.1 <u>Description of the Layout</u>

a) Penetrations utilized

1) No. 1066 - 305' elevation Hayes gas analyzer Room, west wall
   Size = 1'6" x 8"
   El. = 320'6"

2) No. 56 - 305' elevation valve alley corridor floor
   Size = 1'0" x 2'6"
   El. = 301' - 305'

3) No. 195 - 280'6" MU-P-1A Pump Room, west wall
   Size = 6'6" x 2'6"
   El. = 299'3"

4) No. 272 - 280'6" elevation MU-P-1A Pump Room, east wall
   Size = 2'0" x 8"
   El. = 290'

b) Tie In Points

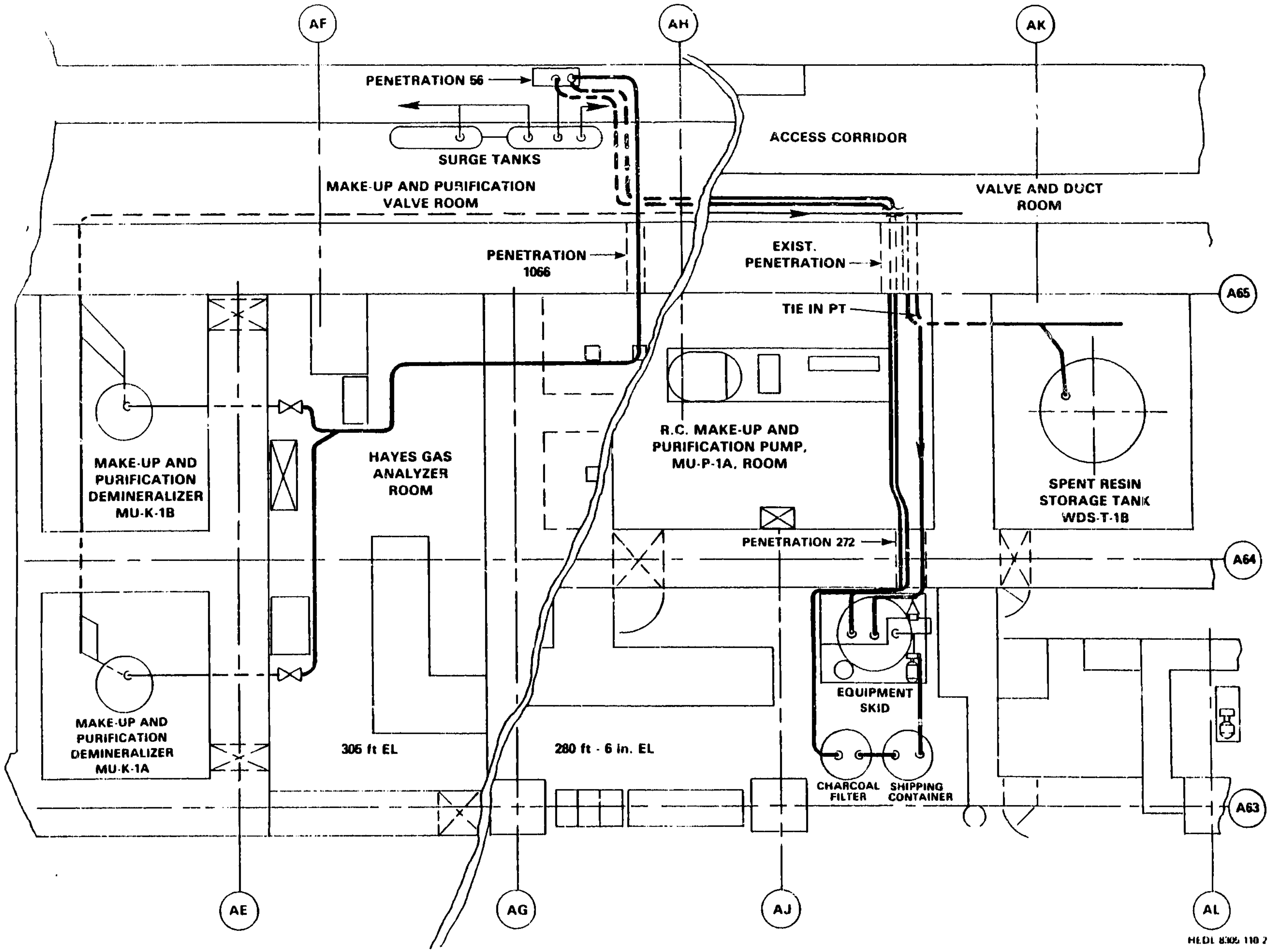
1) The resin sluice tie in point for this approach is in the R.C. Makeup and Purification Pump, MU-P-1A, Room. The line will be cut just as it enters the room through the west wall.

2) Tie into both of the previously cut 3-inch resin fill line outside of each demineralizer cubicle. In the Hayes Gas Room.

FIGURE 4.

UPFLOW - DOWNFLOW RECIRCULATION

## B. SKID ON 280 ft - 6 in. EL.



3) Tie into the top of the Makeup and Purification Filter housing, MU-F-5A, with a special filter cover. This cover matches the original, but includes a section of 2-1/2 inch piping flanged at one end.

c) Skid Equipment

1) 300 Gallon Resin Capture Container

2) Hydrocyclone

3) Transfer Pump

4) Booster Pump

5) Chemical Feeder

6) Chemical Pump

d) Other Equipment Locations

1) Charcoal Filter. This will be placed next to the skid on the east side.

2) Shipping Container. It will set next to the charcoal filter in the most accessible location for a forklift to change containers as required.

3) Surge Tanks. Two tanks will be located on the 305' el. valve Room mezzanine, near columns A65, AF and AH.

e) Piping Runs

1) From the resin sluice tie-in point, the 2 1/2 inch new pipe runs through MU-P-1A Pump Room, out penetration No. 272 and to the equipment skid.

2) A line returns for recirculation from the skid through all four penetrations and into the resin fill lines in the Hayes Gas Room.

3) Another line follows the recirculation line up to the 305' el. to the surge tanks in the valve alley.

4) A line for bleeding the cleaned liquid to the R.C. Bleed Tanks tees from the Recirculation Line and runs to the Makeup Filter, MU-F-5A.

5) Two short lengths of pipe are needed from the skid to the charcoal filter/shipping container and back.

3.2.1.2 Assumptions

a) The penetrations are clear of obstructions that would not allow space for the new 2 1/2 inch piping.

b) The 280' 6" elevation valve and duct alley will be decontaminated as required to make the necessary piping runs.

c) The R.C. Makeup and Purification Pump, MU-P.1A, Room will be decontaminated as required to make all tie-ins and install piping.

d) The area under the 305' el. hatchway is available for changing charcoal filters and shipping containers as needed during the process.

e) The space for the equipment is available and does not interfer with other operations.

3.2.1.3 Advantages

a) The pipe run from resin sluice tie-in point to skid is very short and the recirculation line is not as lengthy as in original layout and will only contain liquid.

b) All pipe runs, except the recirculation line across Gas Analyzer Room, are in areas of little or no traffic, therefore, extra shielding not necessary.

c) The equipment is out of the way of heavy traffic and in an area already requiring personnel protection.

d) Resin will travel downhill from the demineralizers to resin transfer container and will have the advantage of gravity.

3.2.1.4 Disadvantages

a) Since the equipment and containers are on a floor below the loading and storage floor, 305' el., they will have to be hoisted in and out of the hatchway with a crane secured to the 25 ton monorail.

b) The two long piping runs, for recirculation and to the surge tank, increase the total cost considerably.

3.2.2 Alternate 2 - Use of Existing System with WDs Bypassed. See Figure 5.

3.2.2.1 Description of the Layout

a) Penetrations Utilized

1) No. 272 - 280' 6" Elevation MU-P-1A Pump Room, east wall
Size = 8" x 2' - 0" El. = 290'

EXISTING SYSTEM W/RESIN CONTAINER WDS BYPASSED

## B. SKID ON 280 ft - 6 in. EL.

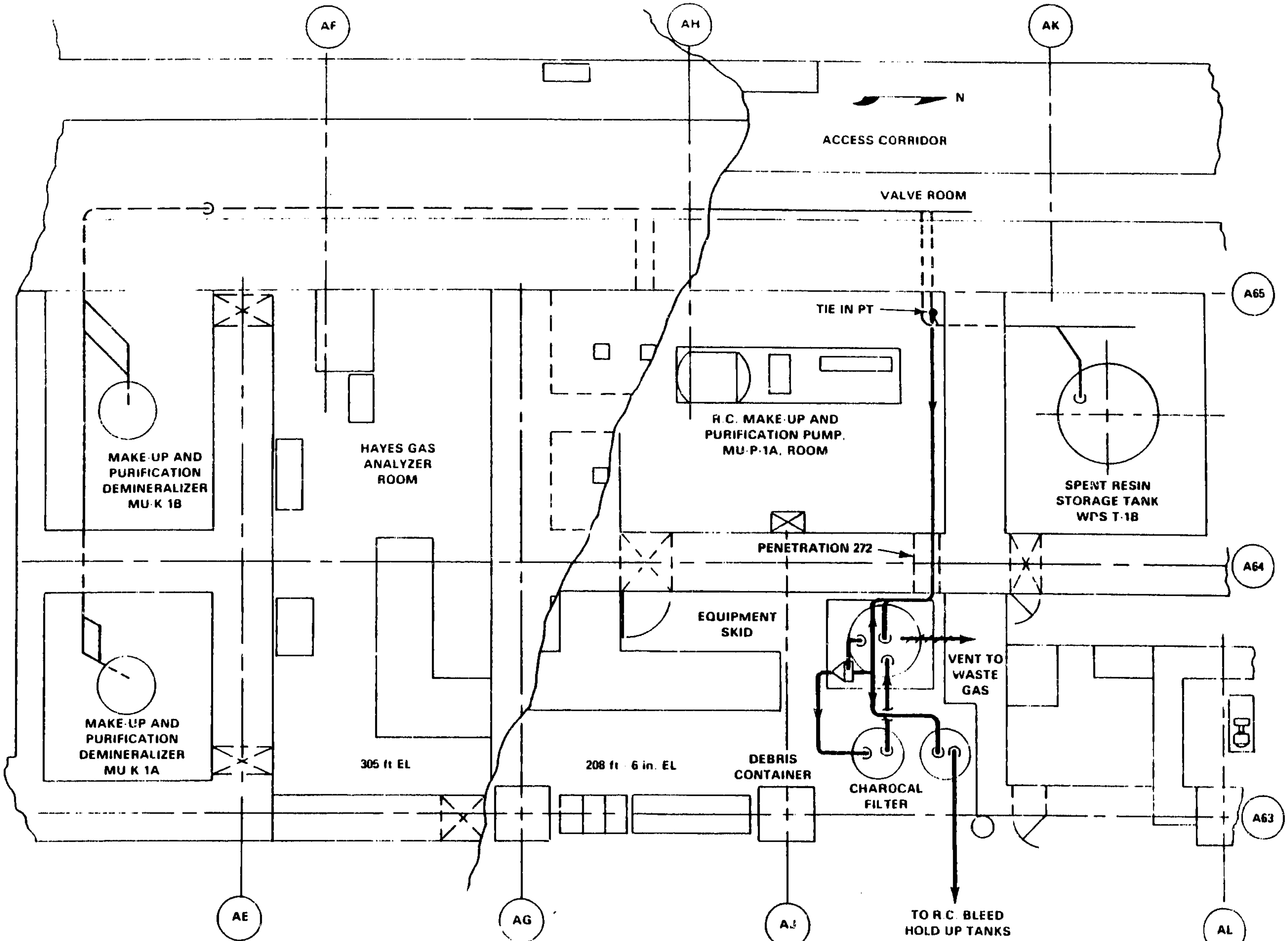



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FIGURE 5.

b) Tie-In Points

1) The resin sluice tie-in point is in the MU-P-1A Pump Room. The line will be cut just as the piping enters the room through the west wall.

2) A tie-in will be made to one of the three R.C. Bleed Holdup Tanks.

c) Skid Equipment

1) 300 Gallon Resin Shipping Container

2) Hydrocyclone

3) Submurged Pump

d) Other Equipment Locations

1) Charcoal Filter. This will be located a few feet from the skid on the east side.

2) Debris Container. This will be placed next to the charcoal filter in the most accessible location for a forklift to change out containers as required.

e) Pipe Runs

1) From the resin sluice tie-in point the 2 1/2 inch new pipe runs through MU-P-1A Pump Room, out penetration No. 272 and to the equipment skid.

2) A line for bleeding the clean liquid from the process runs from the charcoal filter to the first accessible line into the R.C. Bleed Holdup Tanks.

3) Two short lengths of pipe run between the skid and the filter and debris container.

3.2.2.2 Assumptions

Same as Alternate 1.

3.2.2.3 Advantages

a) The equipment is out of the way of heavy traffic and in an area requiring personnel protection.

b) The resin will have the advantage of gravity as it travels 'downhill' to the resin shipping container.

c) The pipe runs are the shortest of all the concepts.

d) All pipe runs are in areas of little or no traffic, therefore, extra shielding is not necessary.

3.2.2.4 Disadvantages

a) Since the equipment and containers are on a floor below the loading and storage floor. 305' el., they will have to be hoisted in and out of the hatchway with a crane secured to the 25 ton monorail.

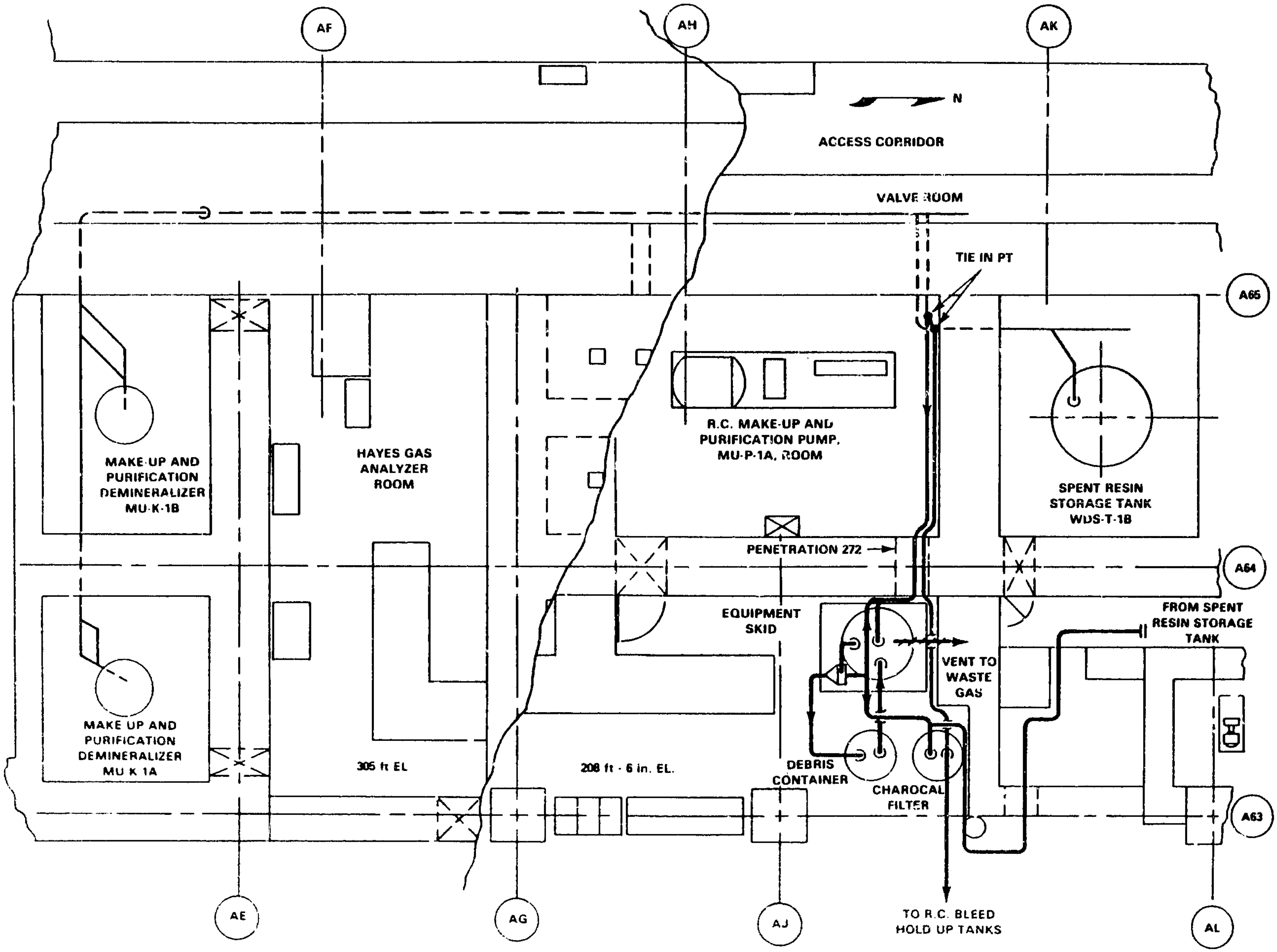
b) The tie-in point to the R.C. Bleed Holdup Tanks requires the longest run of pipe in this concept and possibly a hot tap into the existing piping.

3.2.3 Alternate 3 - Use of existing system with WDS not bypassed. See Figure 6.

FIGURE 6.

EXISTING SYSTEM W/RESIN CONTAINER WDS NOT BYPASSED

## B. SKID ON 280 ft - 6 in. EL.

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3.2.3.1 Description of the Layout

a. Penetrations Utilized

Same as Alternate 2

b. Tie-In Points

1) The resin sluice tie-in point is in the MU-P-1A Pump Room. The line will be cut just as the piping enters the room through the west wall.

2) A tie-in will be made in the resin sluice line near the location in No. 1 above and just before it enters the Spent Resin Storage Tank.

3) A tie-in will be made to one of the R.C. Bleed Holdup tanks.

4) The tie-in for the return line from the Spent Resin Storage Tank will be made near the Spent Resin Transfer Pump Room, close to columns A64 and AK.

c) Skid Equipment

Same as Alternate 2

d) Other Equipment Locations

Same as Alternate 2

e) Pipe Runs

All those in Alternate 2, Plus:

4) A return line will run through penetration No. 272 and adjacent to the resin sluice line to the tie-in for the Spent Resin Storage Tank.

5) A line runs from the tie-in out of the Spent Resin Transfer Pump to the charcoal filter.

3.2.3.2 Assumptions

Same as Alternate 1.

3.2.3.3 Advantages

a) The equipment is out of the way of heavy traffic and in an area requiring personnel protection.

b) The resin will have the advantage of gravity as it travels 'downhill' to the resin shipping container.

c) All pipe runs are in areas of little or no traffic, therefore, extra shielding is not necessary.

d) All tie-in points are in areas close to the skid making for short pipe runs, except for the R.C. Bleed Holdup Tank tie-in.

3.2.3.4 Disadvantages

Same as Alternate 2.

3.3 APPROACH C - Skid in the 305' elevation Valve Room - piping through the corridor.

The skid will set between columns A63 and A64 in the Valve Room - adjacent to the Hayes Gas Analyzer room - with all other containers next to it, though closer to the doorway.

This location was studied in the same manner that the first two areas were, but, upon comparing the gains and drawbacks, it was disregarded as one of the options. Each of the three alternates are similar in respect to tie-in points, penetrations, etc., to the Hayes Gas Analzer Room approach. Therefore, only the advantages and disadvantages will be listed in this evaluation. See Figures 7, 8 and 9.

3.3.1 Advantages

a) All of the equipment is stationed in one room, out of the way of traffic and other clean up activities.

b) All of the equipment is located on one elevation, therefore, a forklift or rollers rather than the crane will be adequate for moving equipment.

c) The Valve Room door is wide enough to move equipment in and to change out containers without removing a knockout wall. Also, it would not be necessary to rearrange any of the existing equipment in order to install the process equipment.

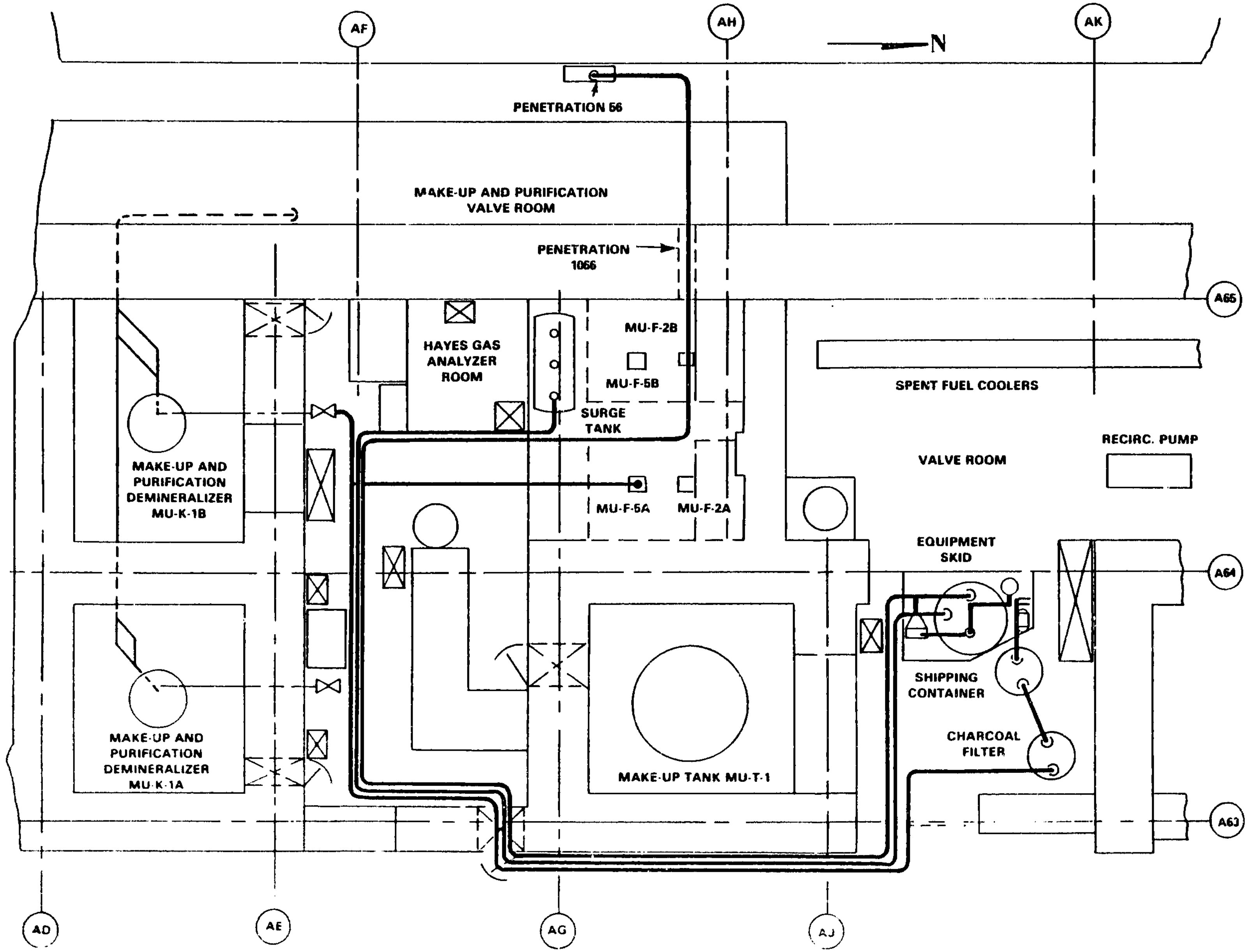
3.3.2 Disadvantages

a) A six foot access way is required through the Valve Room to the Spent Fuel Cooler Room which may not allow enough working space for the process equipment. Also, the piping would be a hinderance in that isle way.

FIGURE 7.

UPFLOW DOWMFLOW RECIRCULATION

## C. SKID ON 350 ft EL. VALVE ROOM - THRU CORRIDOR

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EXISTING SYSTEM W/RESIN CONTAINER WDS BYPASSED

## C. SKID ON 350 ft EL. VALVE ROOM - THRU CORRIDOR

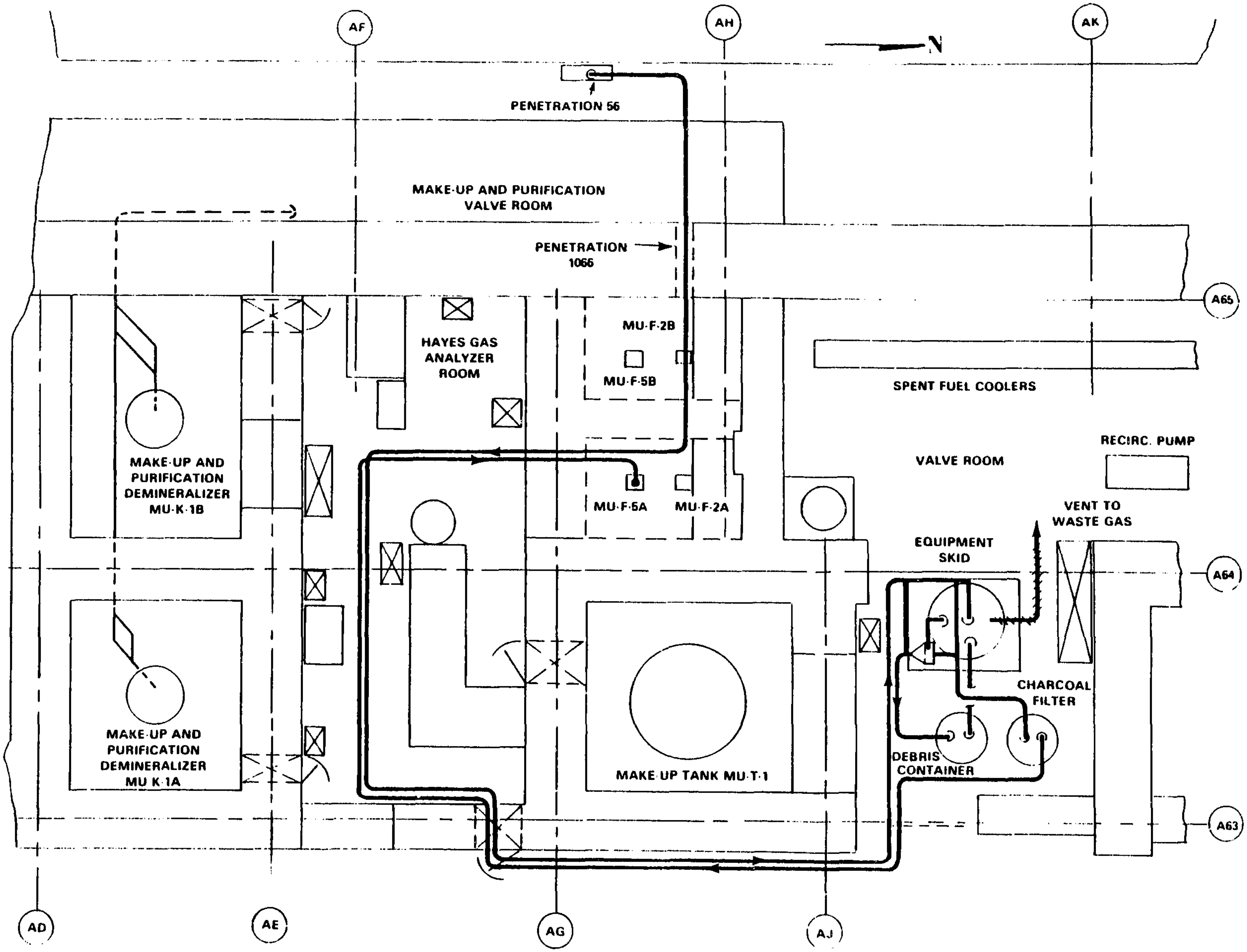


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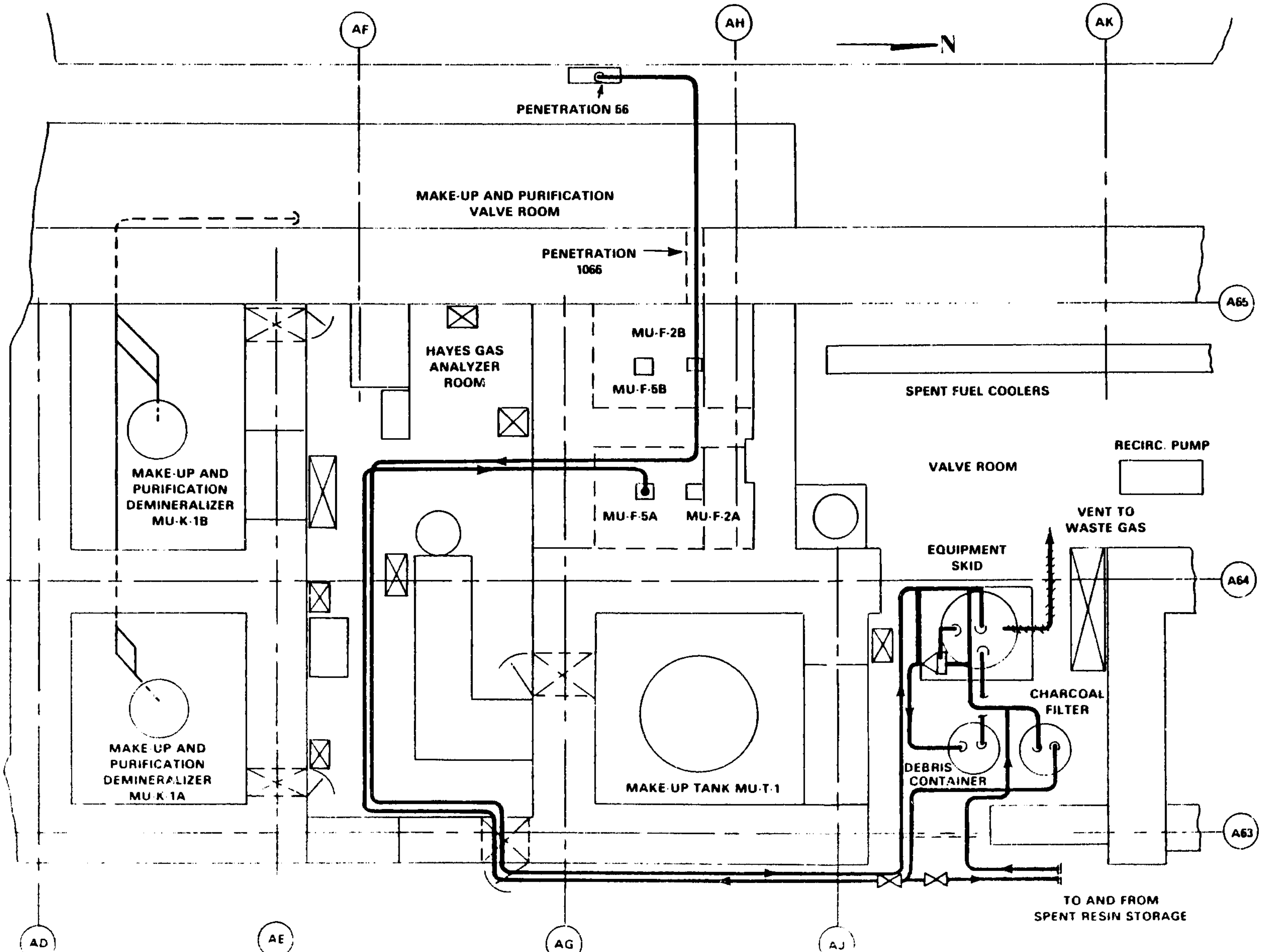
FIGURE 8.

FIGURE 9.

EXISTING SYSTEM W/RESIN CONTAINER WDS NOT BYPASSED

## C. SKID ON 350 ft EL. VALVE ROOM - THRU CORRIDOR

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b) The piping runs through the corridor between the skid and the demineralizers. Since the 305' elevation requires no protection and has a fair amount of activity, this may be a safety hazard because of the highly radioactive resin being transferred. Also, these pipe runs are quite long.

## 3.4 APPROACH D - Skid in the 305' elevation Valve Room - piping through the wall.

This location is identical to Approach C with a different piping route to eliminate some of the safety problems. The entire approach for all three alternates was researched, but disregarded as in Approach C. Listed below are the advantages and disadvantages for justifying this decision. See Figures 10, 11, and 12.

### 3.4.1 Advantages

All of those in Approach C, plus:

d) The piping runs through the core-drilled wall between the Hayes Gas Room and the Spent Fuel Cooler Room. This not only shortens the piping considerably, but reduces the safety risk by keeping all hot piping out of heavy traffic ways.

### 3.4.2 Disadvantages

a) There must be a six foot accessway through the Valve Room to the Spent Fuel Cooler Room, which may not allow enough working space for the new process equipment. Also, the piping would be a hinderance in that isle way.

b) The Spent Fuel Cooler Room is caged off. Therefore, installation of piping and shielding in that area may be impossible.

FIGURE 10.

UPFLOW DOWNFLOW RECIRCULATION

## D. SKID ON 305 ft EL. VALVE ROOM - COREDRILL WALL

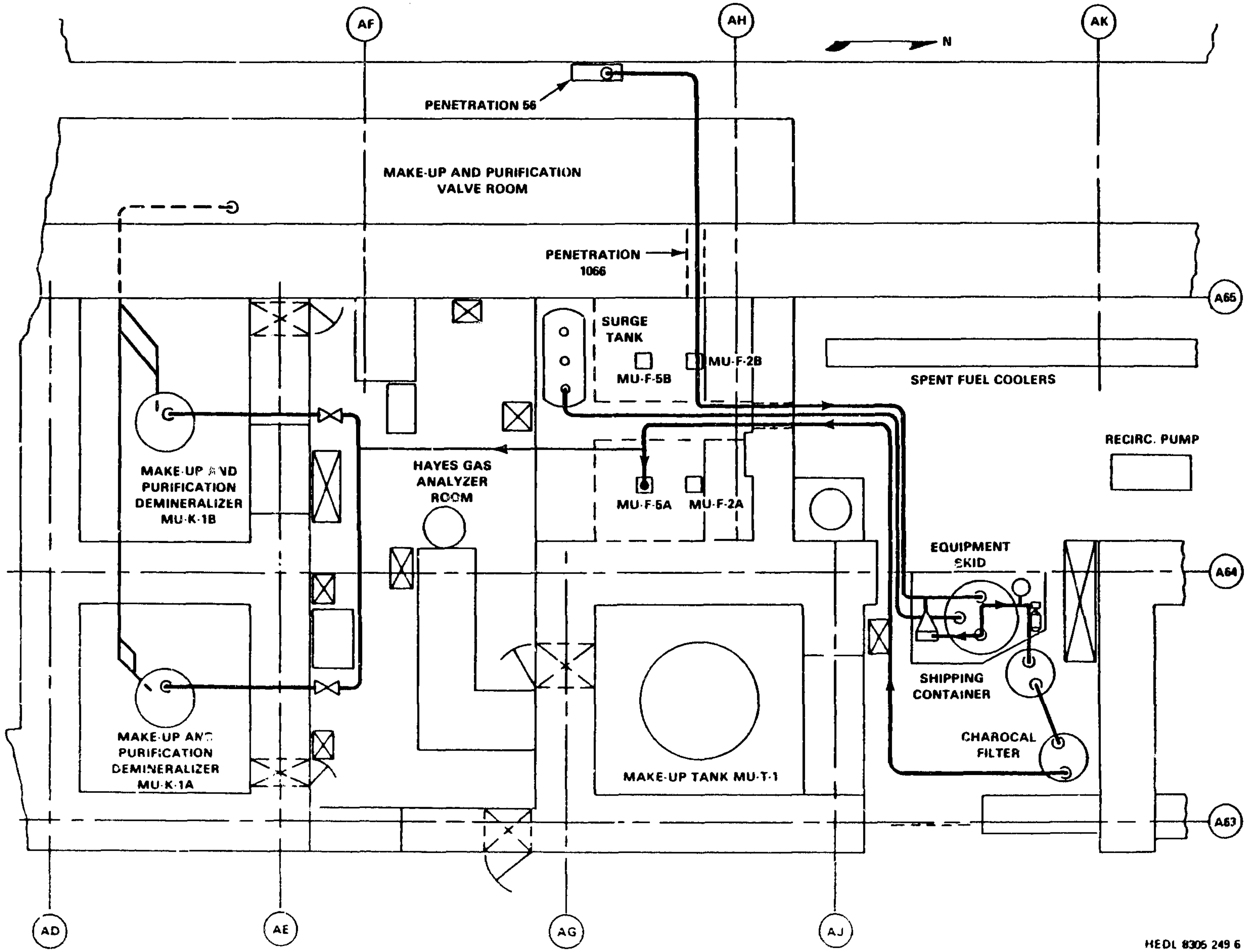
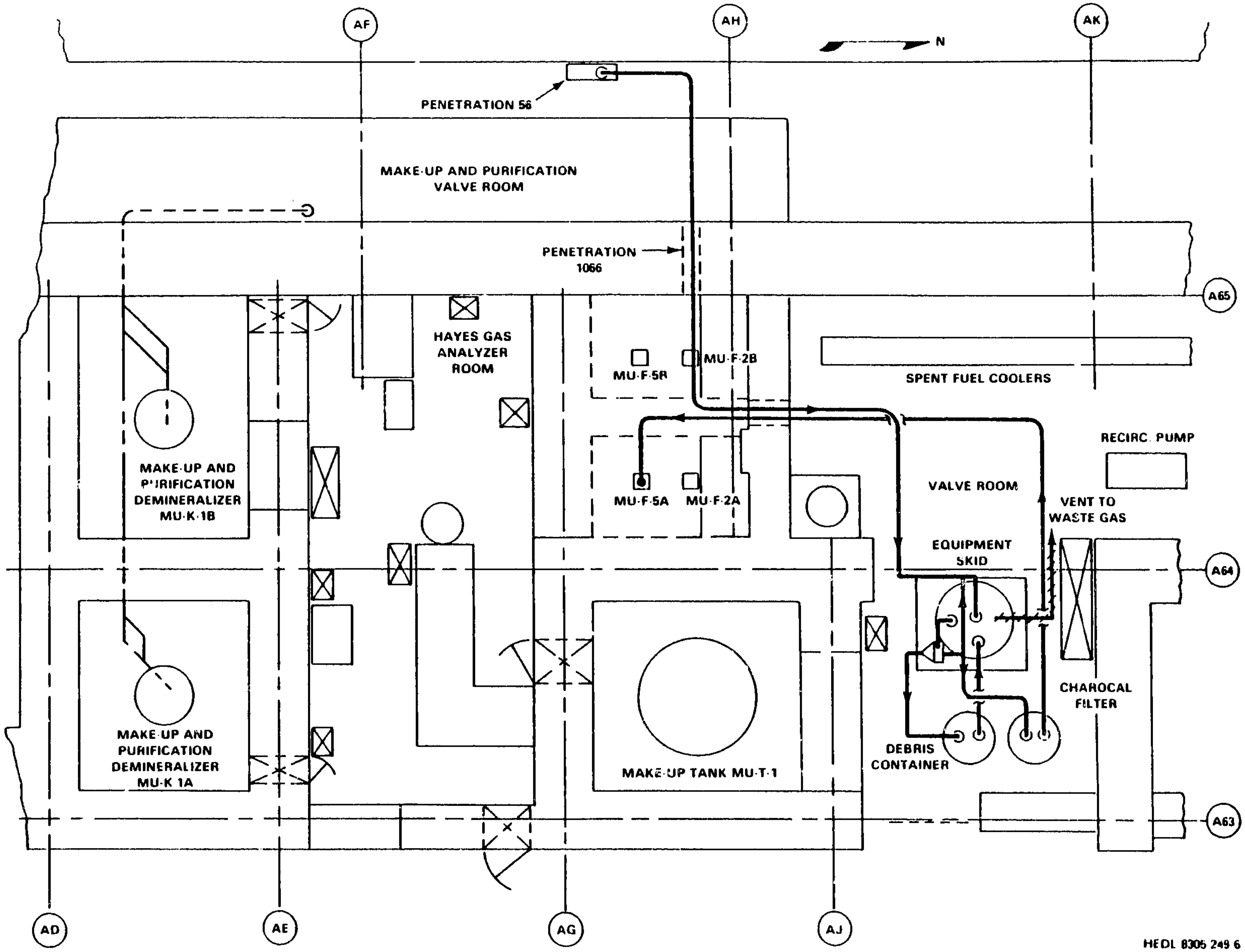


FIGURE 11.

EXISTING SYSTEM W/RESIN CONTAINER WDS BYPASSED

## D. SKID ON 305 ft EL. VALVE ROOM - COREDRILL WALL

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EXISTING SYSTEM W/RESIN CONTAINER WDS NOT BYPASSED

## D. SKID ON 305 ft EL. VALVE ROOM - COREDRILL WALL

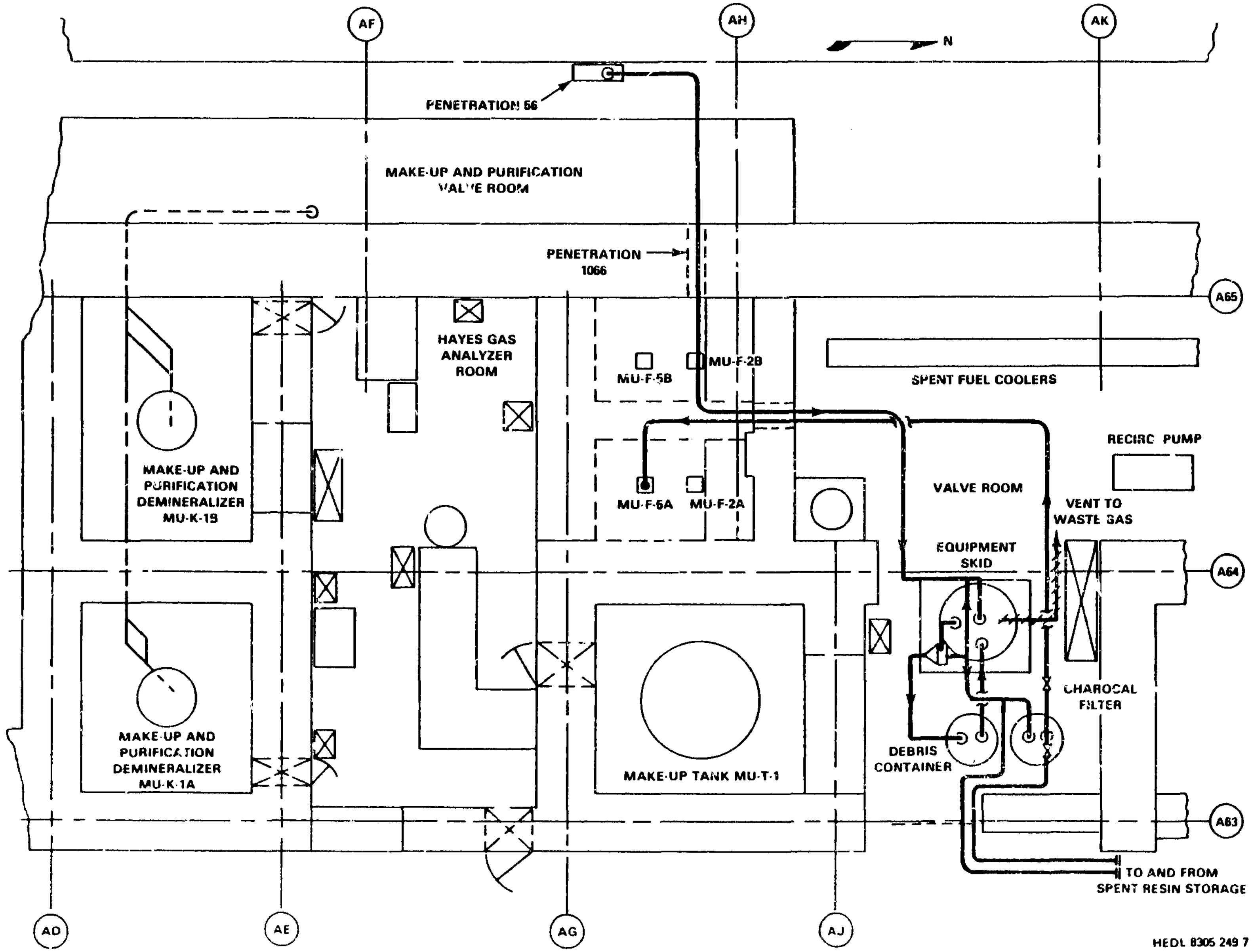


FIGURE 12.

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1. M. K. Mahaffey, E. J. Renkey, W. W. Jenkins, L. M. Martinson, R. D. Hensyel, "Resin and Debris Removal System Conceptual Design," HEDL-7335, Draft Report.

2. E. P. Vodney, Controller Westinghouse Hanford Company, to J. J. Sutey, Director, Budget Division, DOE - "In FY-83 Budget Revisions for TMI-2 Demineralizer Resin Removal," 18351230, April 11, 1983.

3. W. W. Jenkins, "TMI-2 Resin Removal - Concepts for Use of Spent Resin Storage Tanks", Study for Planning Study Document, April 22, 1983.

4. Burns and Rue, Inc., Drawing No. 2066, W.O. 2555, Rev. 19, "General Arrangement Auxiliary and Fuel Handling Building Floor Plan, El. 305'-0"."

5. Burns and Roe, Inc. Drawing No. 2065, W.O. 2555, Rev. 23, "General Arrangement Auxiliary and Fuel Handling Building Floor Plan El. 258'6" & 280'-6"."

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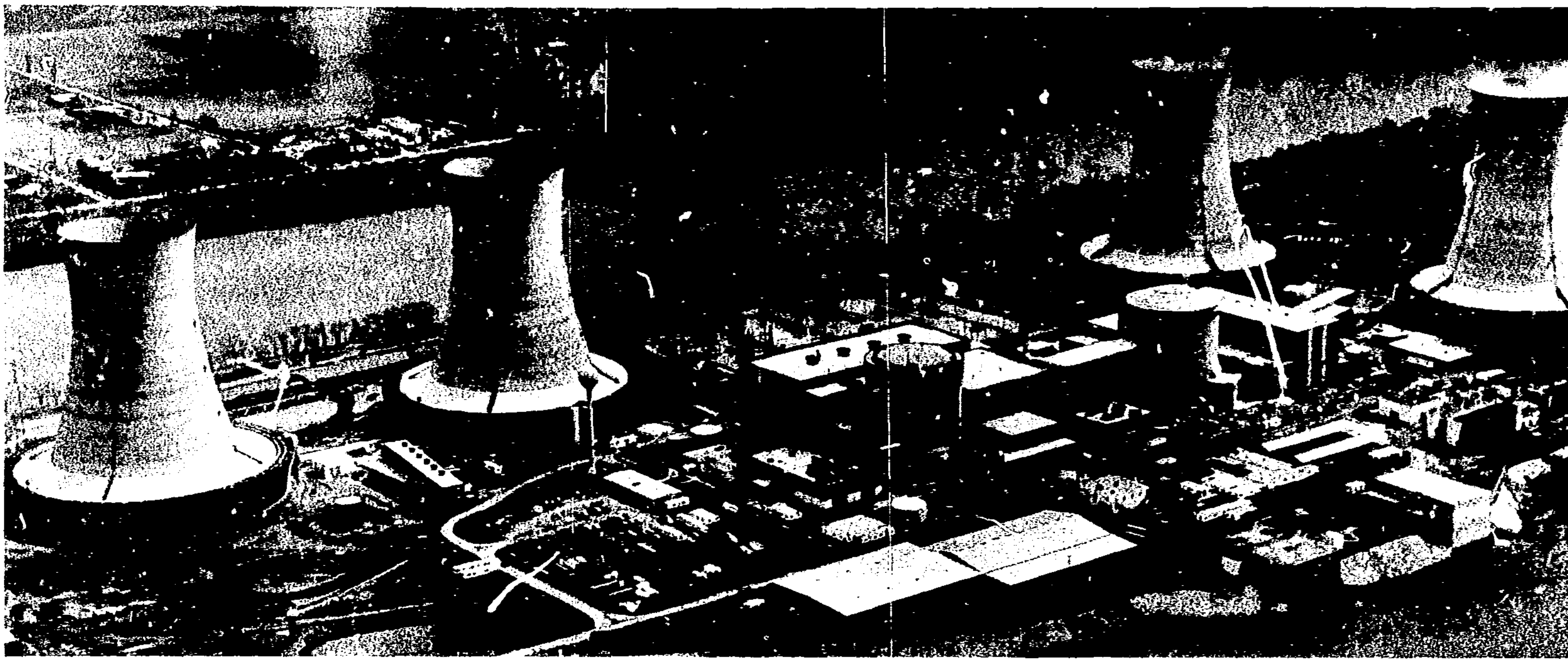

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# FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-211


J. E. Jones
J. T. Smith
M. V. Mathis



U.S. Department of Energy
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-76IDO1570

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# FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-211

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# 1. INTRODUCTION

During and following the TMI-2 accident, a number of instruments failed or were suspected of providing erroneous readings. Because of this problem, industry concerns were focused upon the behavior of instrumentation under adverse conditions. To better understand failure mechanisms, the Technical Integration Office (TIO) contracted Technology for Energy Corporation (TEC) to perform field measurements on a set of selected instruments to determine current in-situ operating characteristics. For some instruments, these measurements were to be performed prior to removal (and replacement with new instruments) in order to have a cross reference with post removal observations.

This report provides the information gathered by TEC on the area radiation monitor HP-R-211. This detector was located at 305 feet elevation, just inside the entry hatch (ante-room) used during initial entries into containment. This instrument consisted of a Victoreen Model 857-2 detector assembly connected to a Victoreen Model 856-2 panel alarm and approximately 520 feet of interconnecting cable. This instrument was believed to have failed due to low radiation level indications and due to a lack of response to the manually activated checksource in the detector. As a result of this failure, the detector was a candidate for early replacement to provide long-term radiation monitoring capability inside containment at the entry hatch.

## 2. INSTRUMENT LOCATION, CABLING, AND TERMINATIONS

A review of appropriate drawings from Victoreen and Burns & Roe (itemized in the Appendix in the measurement procedure, page A-5) resulted in the composite electrical diagram shown in Figure 2-1. From this information, Table 2-1 gives a list of the appropriate termination points for performing measurements in the Control Room in Cabinet 12. Also noted in Figure 2-1 are the cable lengths pulled during instrument installation (before final trimming) between each termination and/or junction point.

The detector assembly is a Victoreen Model 857-2 which is shown in Figure 2-2 along with required interfacing connections to the readout module. Figure 2-3 shows the functional layout of the detector and associated readout module. This assembly is a "medium range" device with a range of 0.1 to $10^4$ mR/hr. An electrical diagram of the detector circuit is shown in Figure 2-4. As shown in Figure 2-1, the circuit is somewhat complicated by the presence of a remote alarm/meter which is used as a local indication of the radiation levels inside the entry hatch.

Since measurements were being made in the control room, there was no way to remove the effect of the remote meter (attached to the signal line) from the observed instrument response. However, since the remote meter was located outside containment, it did not experience severe operating environments and thus was not considered to present any measurement problems. Similarly, the Model 856-2 Readout Module, located in the control room, was not specifically considered to be a source of instrumentation problems except in its function of supplying power to the detector assembly.

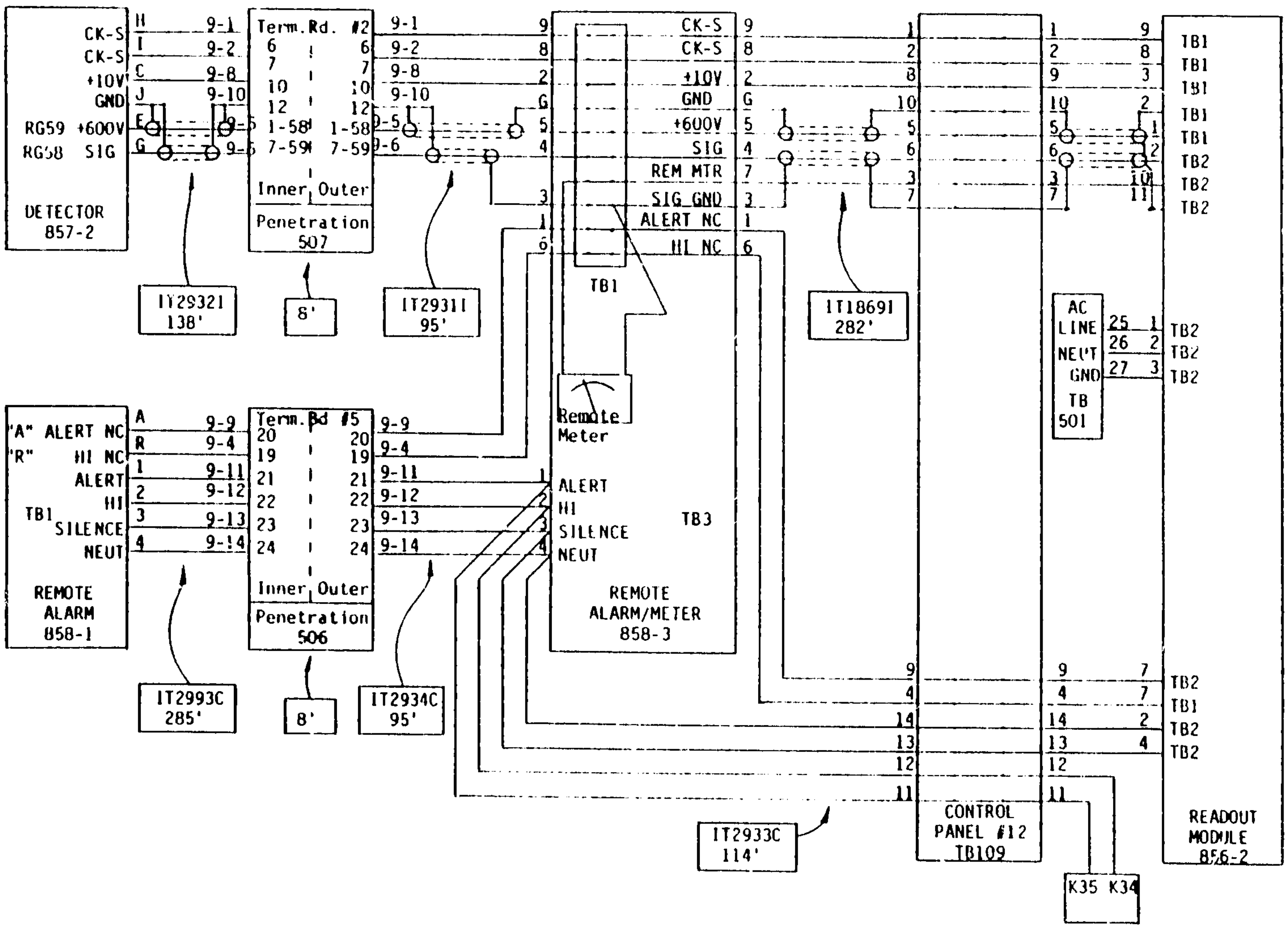


Figure 2-1. HP-R-211 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-211 MEASUREMENTS

| Signal | Cabinet 12 Identification* |
|---|---|
| +10V Power Supply | TB109-8 |
| +600V High Voltage | TB109-5 |
| Signal Out | TB109-6 |
| Ground | TB109-10 |
| CS** | TB109-1 |
| CS** | TB109-2 |

*From cable IT2931I

**CS = Checksource coil positive and return contacts (exact identification not necessary).

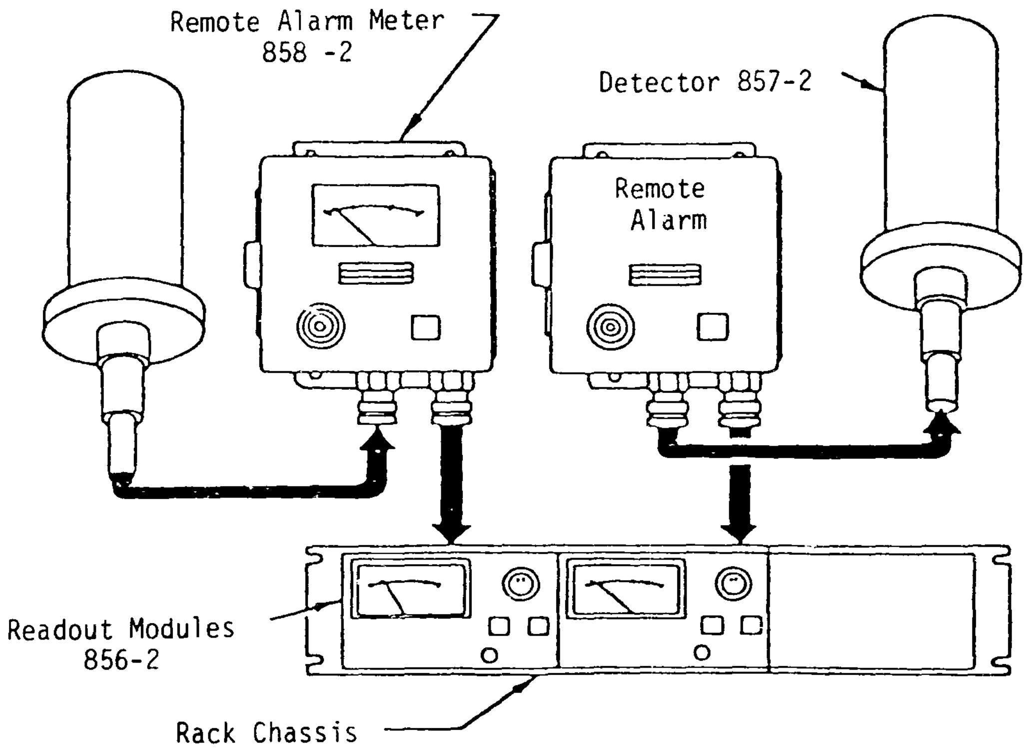



Figure 2-2. Sketch of Instrumentation for HP-R-211.

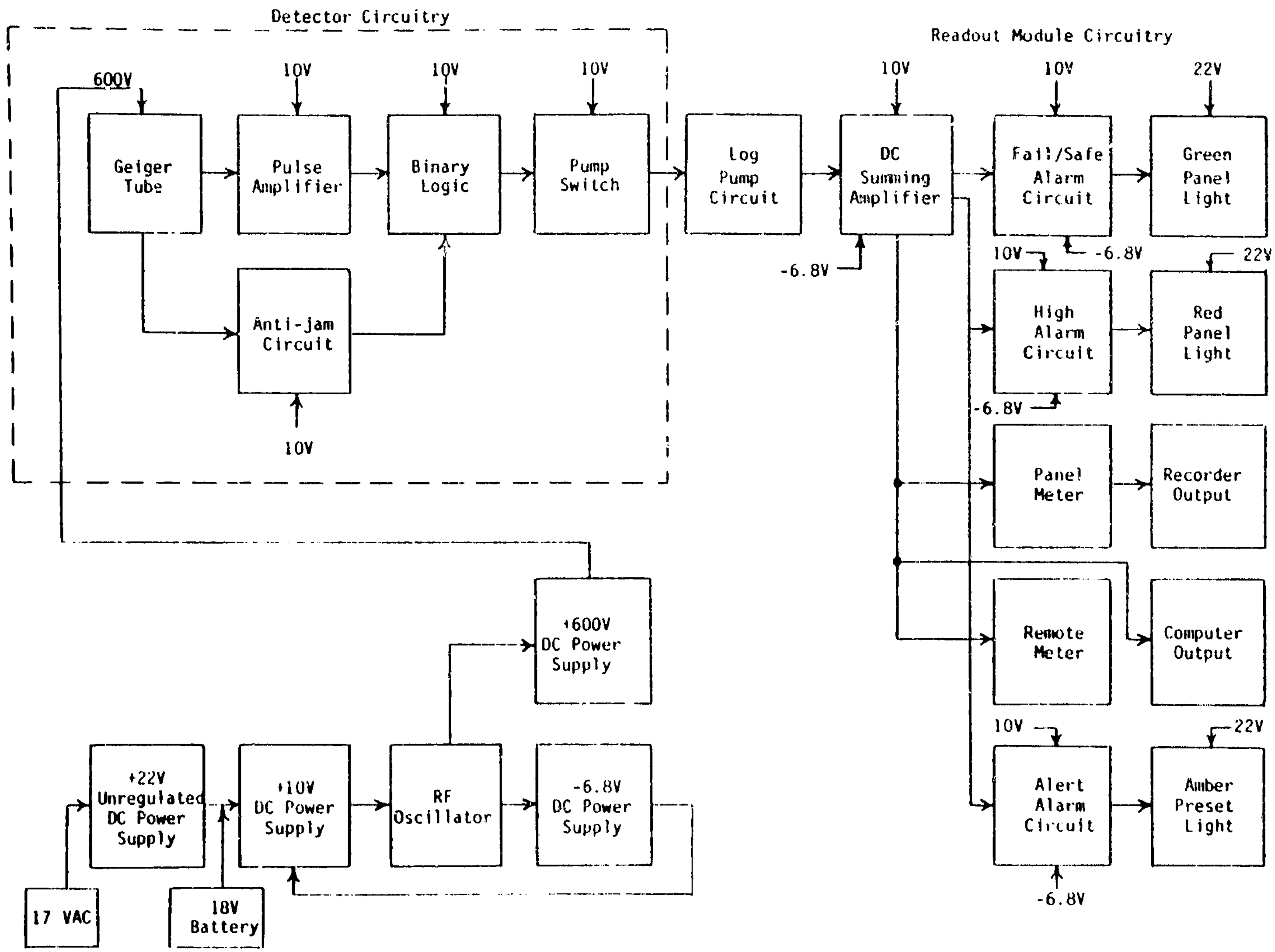



Figure 2-3  Functional Layout of Detector and Readout Module.

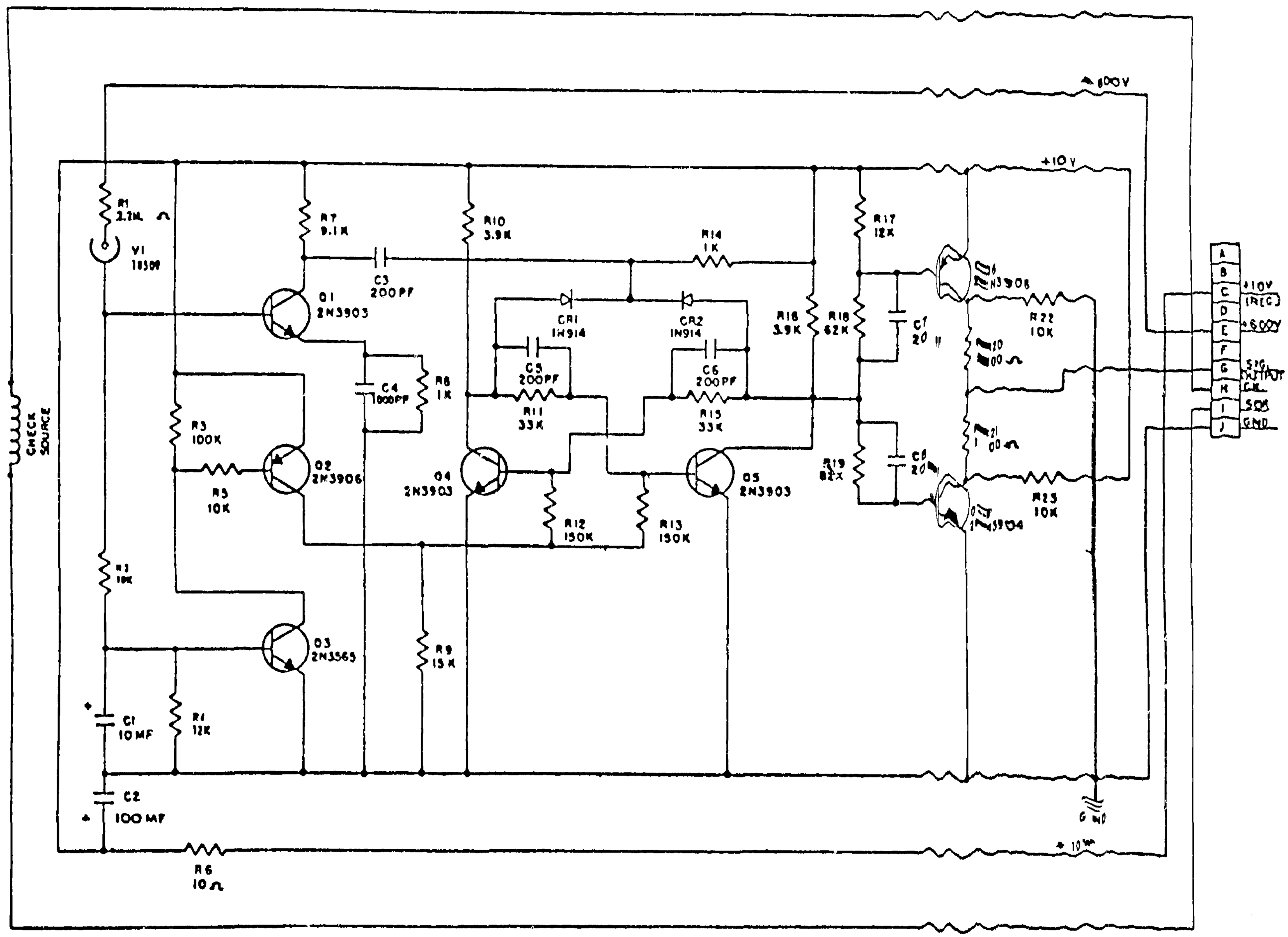


Figure 2.4 Electrical Circuit of Detector Card

# 3. PREPARATION OF MEASUREMENT PROCEDURES

As a result of generating the composite electrical diagram and from a review of the Victoreen Area Monitor Operation Manual, the major types of measurements to be performed were identified as

1. Determine as-found condition of Readout Module and Remote Meter and record signal output
2. Perform passive measurements (i.e., passively monitor signals) on each electrical connection consisting of time domain waveforms, very-high frequency spectrum analysis (i.e., MHz region), and frequency spectra below 100 kHz
3. Perform resistance, capacitance, impedance, and Time Domain Reflectometry (TDR) active measurements (i.e., actively introducing a test signal).

These measurements were designed to verify the operation of the Readout Module (especially the power supplies) and the Remote Meter/Alarm. The focus of the measurement was on the detector assembly, cabling, and terminations/connections to the assembly. The Appendix contains the detailed procedure which was followed during the measurement program, and a summary of measurements is presented in the next section.

# 4. MEASUREMENTS

Since HP-R-211 was a candidate for removal and possible replacement, measurements were attempted at five different conditions:

1. Laboratory measurements on a spare detector and readout module assembly
2. Pre-insertion detector pin measurements on two spares
3. Measurements on the installed detector-readout assembly
4. Measurements with a replacement detector installed at the remote meter location
5. Attempted measurements on the newly installed detector (only TDR cable measurements were possible).

Each set of measurements is described in the following sections.

## 4.1 LABORATORY MEASUREMENTS (MOCK-UP)

Prior to performing the measurements on the installed instrumentation, a preliminary set of measurements were taken on a spare detector and readout module assembly. Pages A-3 to A-16 in the Appendix are the actual field data sheets for the measurements. A summary of the important data is presented in Table 4-1. Of equal importance to the measurements on the detector were the calibration data obtained on the equipment to be used for the field tests. Pages A-17 to A-22 show the results of these measurements with the resulting equipment calibration (i.e., conversion values) data.

Table 4-1

SUMMARY OF MOCK-UP MEASUREMENTS
(DETECTOR RESISTANCES)

| Measurement Points | Polarity + | Polarity - |
|---|---|---|
| Checksource (+)<br>Checksource (-) | 30.4 ohms | 30.4 ohms |
| Signal in<br>Shield | 8.85 | 7.23 |
| Signal in<br>+10V | --- | --- |
| Shield<br>+10V | 7.47 | 11.90 |

Notes: (a) All values in ohms x $10^3$ unless otherwise indicated

(b) First signal to positive terminal and second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM on $20 \times 10^3$ ohm scale.

## 4.2 PRE-INSERTION DETECTOR PIN MEASUREMENTS

Prior to possible insertion into containment for replacement of HP-R-211, measurements were made on two detector connector pins to determine a typical range of normal values for resistances. These measurements were carried out on two different Model 857-2 detectors, serial numbers 111 and 1405. Table 4-2 shows the data obtained from these pin measurements which was used for later comparison to the data obtained from the HP-R-211 assembly. Note that there is only a small variation in measured values between the detectors and that the change in resistances with polarity is the result of active components (i.e., transistors) in the detector circuitry.

## 4.3 INSTALLED DETECTOR-READOUT MEASUREMENTS

Measurements were also performed on the HP-R-211 assembly in its as-found condition. The field data sheets for these measurements are shown in the Appendix on pages A-23 to A-41. When measurements began, the local and remote meters were indicating 1.5 and 3.5 mR/hr, respectively. Prior to performing further measurements, a recording of the Signal Out line was made on an FM tape recorder using AC coupling to remove an offset of approximately 7V in the signal. Following this recording, passive measurements were made on certain signals with the following results:

(a) 10V Power Supply @ 9.4V

(b) Signal DC Voltage @ 7.5V with no checksource

@ 7.5V with checksource

Table 4-2

SUMMARY OF DETECTOR PIN RESISTANCE MEASUREMENTS

| Measurement Points | Detector #111 | | Detector #1405 | |
|---|---|---|---|---|
| | Polarity + | Polarity - | Polarity + | Polarity - |
| Checksource (+) Checksource (-) | --- | --- | 30 ohms | 30 ohms |
| Signal In Shield | 8.77 | 7.34 | 8.79 | 7.16 |
| Signal In +10V | 8.27 | 6.56 | 8.38 | 6.84 |
| Shield +10V | 7.44 | 11.77 | 7.37 | 11.84 |

Notes: (a) All values are in ohms x $10^3$ unless otherwise indicated

(b) First signal to positive terminal; second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM or $20 \times 10^3$ ohm scale.

(c) 600V Power Supply @ 605V

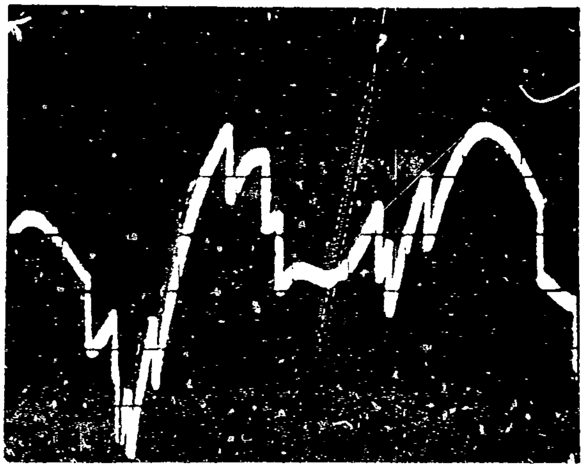
(d) Checksource Current @ 13 ma.

These measurements indicated that the 10V power supply was somewhat low, that the signal did not significantly change when the checksource was applied, that there was an offset in the signal line (detected during earlier recording), and that the 600V supply and checksource coil were operating correctly.

A series of time plots of all instrument line responses were obtained by photographing the trace from a storage oscilloscope. Figures 4-1 to 4-3 show typical results of these measurements for the 600V supply, signal, and 10V supply, respectively. The complete set of photographs is shown in the Appendix on pages A-79 to A-86. Frequency domain spectrum plots were also obtained for each signal over both a 0-5 MHz band and a 0-100 kHz band and the complete set of data can be found on pages A-87 to A-92. Figures 4-4 to 4-6 show the 0-100 kHz plots of the signal spectra, but not the high-frequency band, since little information is present at those frequencies. From these measurements of the waveforms, the following summary is obtained:

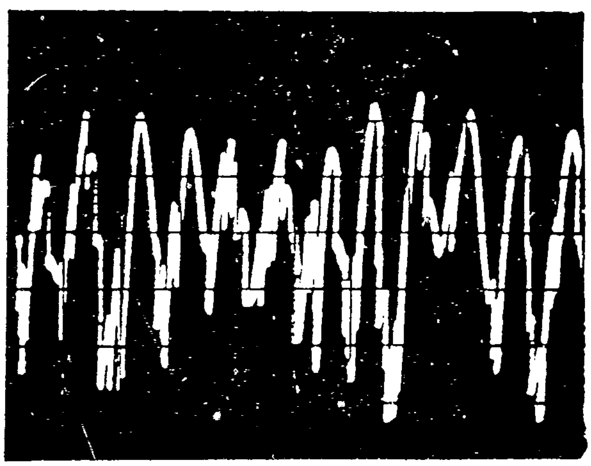
(1) 600V supply: 1V P-P @ 120 Hz present
small 20 kHz and harmonics
small 95 kHz present
random pulses present (see 1/f spectrum)
at lower frequencies

(2) Signal : 3.4V P-P random pulses present
small 32 kHz and harmonics present



a) Vertical Scale
0.2V/Div

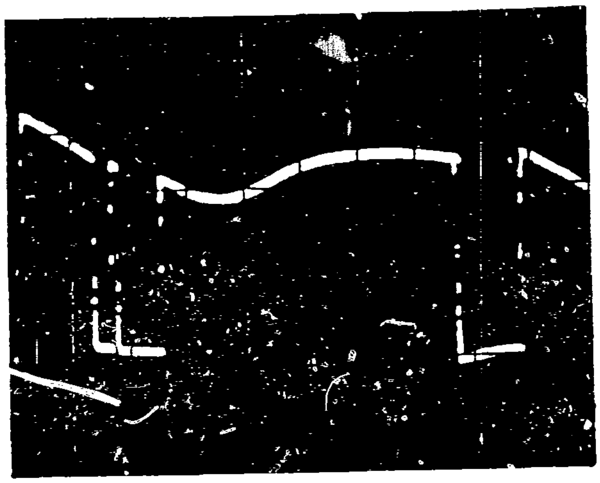
Horizontal Scale
2 ms/Div



b) Vertical Scale
0.2V/Div

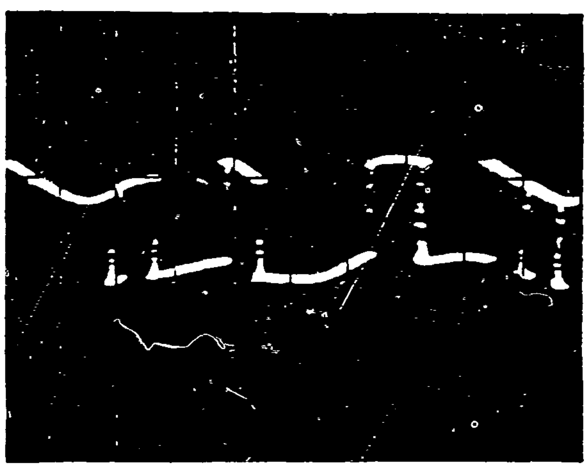
Horizontal Scale
10 ms/Div

Figure 4-1. Typical AC Fluctuations Present on 600 V Supply.



a) Vertical Scale
1V/Div

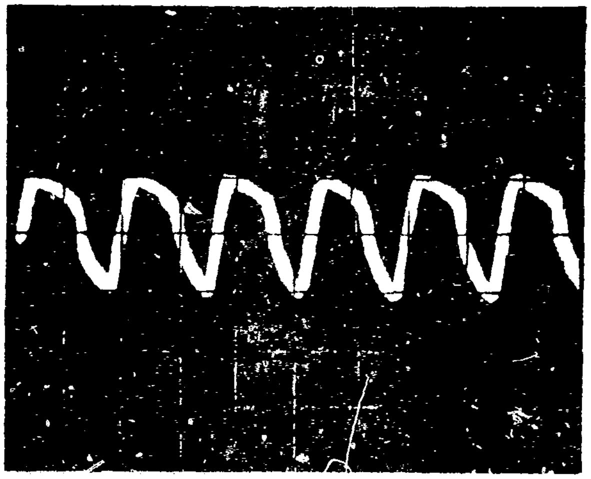
Horizontal Scale
1 ms/Div



b) Vertical Scale
1V/Div

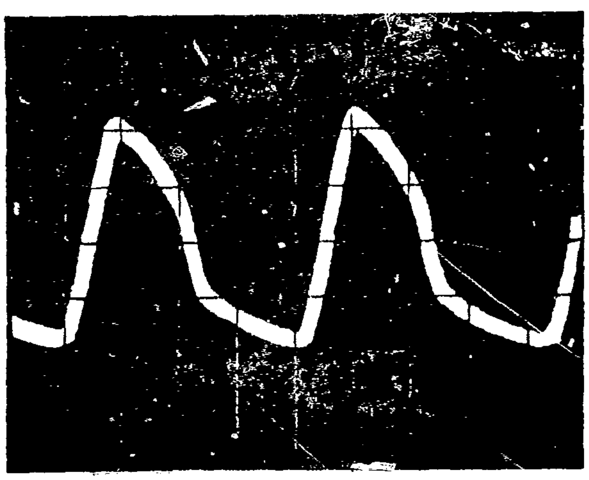
Horizontal Scale
2 ms/Div

Figure 4-2. Typical Output Signal.



a) Vertical Scale
1V/Div

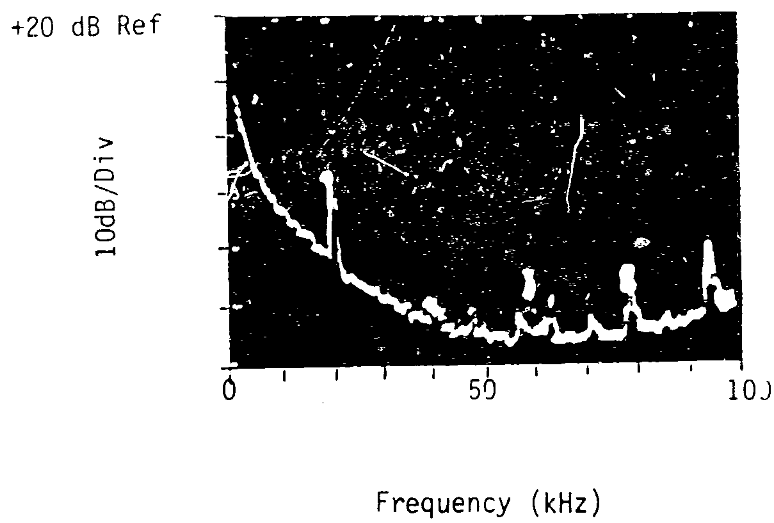
Horizontal Scale
5 ms/Div



b) Vertical Scale
0.5V/Div

Horizontal Scale
2 ms/Div

Figure 4-3. Typical Fluctuations on the 10 Volt Power Supply.

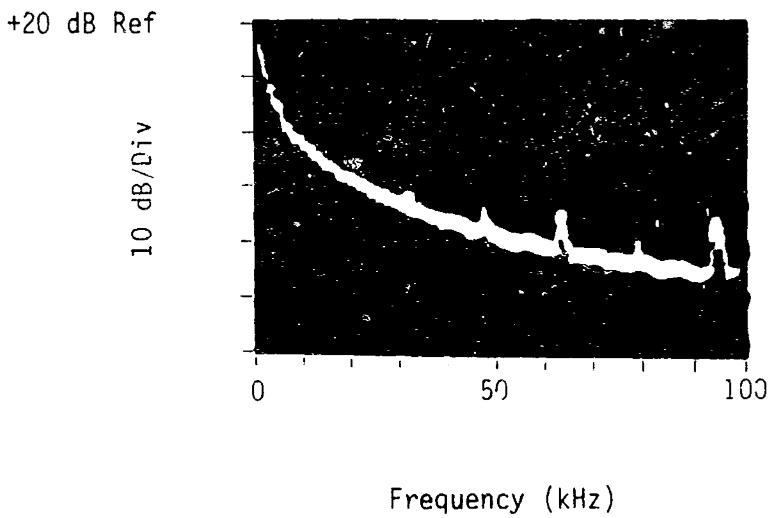



Note:

20 kHz Harmonics Intensified

AC RMS = 0.109 Volts

Figure 4-4. Frequency Spectra for 600 Volt Power Supply.

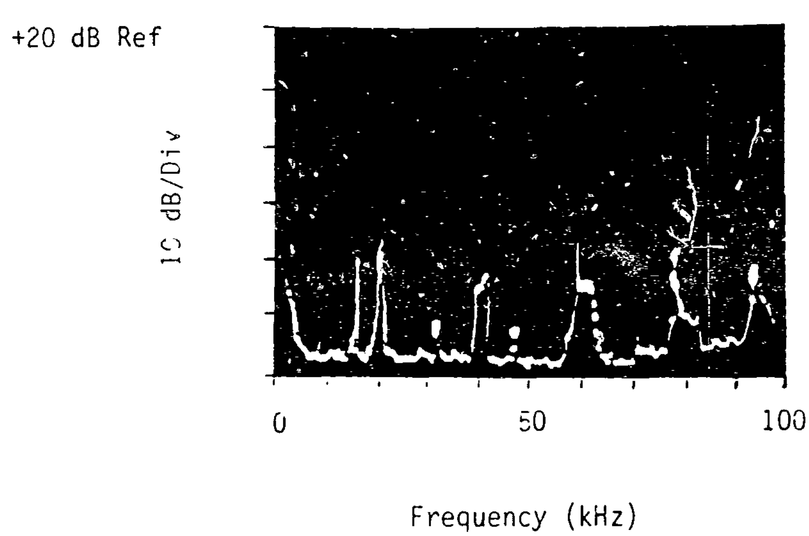



Note:

32 kHz Harmonics intensified

AC RMS = 1.35 Volts

Figure 4-5. Frequency Spectra for Output Signal.



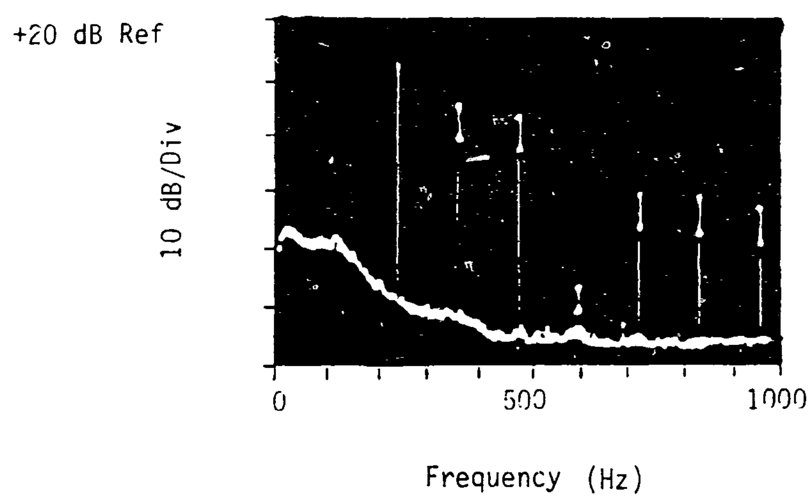

a) 0-100 kHz Range

Note:

16 kHz Harmonics Intensified

20 kHz Harmonics Present

AC RMS = 0.301 Volts




b) 0-1 Hz Range

Note:

120 Hz Harmonics Intensified

AC RMS = 0.712 Volts

Figure 4-6. Frequency Spectra for 10 Volt Power Supply.

(3) 10V supply : 2V P-P @ 120 Hz present
small 16 kHz and harmonics present
small 20 kHz and harmonics present.

This data again indicates a problem in the 10V supply due to the excessive 120 Hz AC present. Another problem is obvious in the small amplitude of the Signal pulses since they should span approximately 10V.

After completion of these measurements, the normal instrument calibration procedure was performed on the readout module electronics. The raw data sheets from the calibration are given on pages A-62 and A-63.

Application of the calibration procedures resulted in replacement of a capacitor in the +22V supply in the readout module, which directly feeds the 10V supply. This capacitor was the cause of the low supply voltage and probably caused the excessive 120 Hz fluctuations by allowing the rectified AC line signal to pass through. After the calibration, all voltages were restored to normal values.

After calibration of the readout module, power was removed from the instrument and the field cable links were opened between the detector and the readout module. A series of capacitance and impedance measurements were made at the field side (directly to detector) of the terminal blocks. The data obtained from this test is erratic due to the presence of long cables and active components in the detector, but may be found on page A-39 of the Appendix.

The integrity of the cable between the control room cabinet and the detector was then tested by performing TDR measurements. Figure 4-7 shows a typical TDR result for the Signal Out line with inflection points identified, and Table 4-3 lists the inflection points for all lines measured. Notice that there is some scatter in the predicted location of electrical interfaces, but this is not unexpected when using TDR measurements. A complete set of TDR traces for all cables can be found in the Appendix on pages A-94 to A-107.

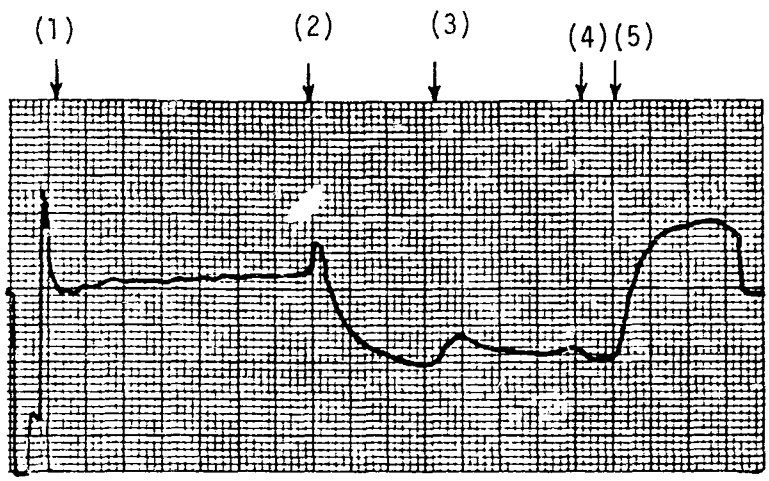
Upon completion of the TDR measurements, resistance measurements were performed on all combinations of signal lines at the terminal block. Note that this measurement is different from the detector pin measurements due to the length of cabling between the detector and the terminal block. However, this effect should be small (as confirmed by TDR data) and results should be comparable to the data taken previously. Table 4-4 lists the important measurements and a complete list can be found on page A-41.

## 4.4 MEASUREMENTS FOLLOWING REMOTE INSTALLATION OF NEW DETECTOR

Following the completion of measurements on the installed HP-R-211 system, a replacement model 887-2 detector (serial # 111) was installed by removing connections to the containment detector at the ante-room (remote) junctions. Before proceeding with measurements, the normal field calibration was performed on the detector-readout system using a calibration source. An adjustment to change the meter readouts upward by approximately a factor of two was needed, which is not unusual for expected variations with a new detector. The TMI calibration data sheets are given in the Appendix on pages A-64 to A-67.

Legend

(1) End of connecting cable & terminal
(2) Terminal block R increase
(3) Terminal block R increase
(4) Start of reduced R cable
(5) End of cable




Horizontal Scale:
26.3 ft/Div

Vertical Scale:
0.1 V/Div
(500 mρ/Div)

Figure 4.7 TDR Results of Signal Out Cable.

Table 4-3

SUMMARY OF TDR INFLECTION POINTS

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| Checksource | 163 | Increased R point | terminal block |
| | 253 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 379 | Large R increase | checksource coil |
| +600V (RG59) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 268 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 405 | Large R increase | detector circuitry |
| Signal (RG58) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 263 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 395 | Large R increase | detector circuitry |

Table 4-3 (Continued)

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| +10V | 163 | Increased R point | terminal block |
| | 242 | Increased R point | terminal block |
| | 342-358 | Slight R decrease | ? |
| | 379 | Large R increase | detector circuitry |
| Signal (RG58) with terminal block added | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 363 | Increased R point | terminal block |
| | 384 | Slight continuous R decrease | ? |
| | 405 | Large R increase | detector circuitry |

*TDR to terminal block test cable (10 ft) not included in distance.

**R is the abbreviation for resistance.

Table 4-4

RESISTANCE DATA FROM HP-R-211

| Measurement Points | Polarity + | Polarity - |
|---|---|---|
| Checksource (+)<br>Checksource (-) | 40.2 ohms | 40.2 ohms |
| Signal in<br>Shield | 8.62 | 6.53 |
| Signal in<br>+10V | 305 ohms | 305 ohms |
| Shield<br>+10V | 6.47 | 8.59 |

Notes: (a) All values in ohms x $10^3$ unless otherwise indicated.

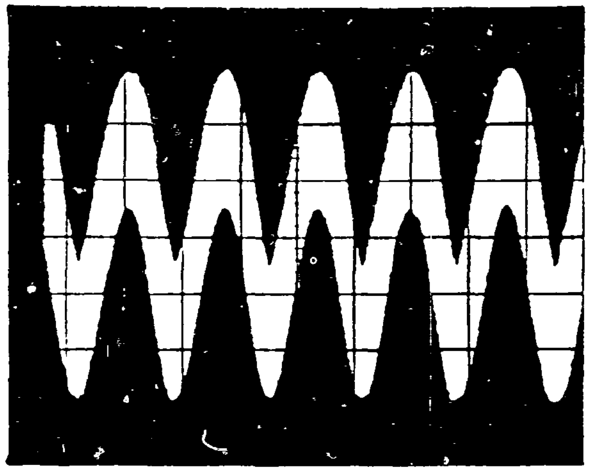
(b) First signal to positive terminal and second to negative is considered Polarity +.

(c) All measurements made with a Keithley 177 DVM on $20 \times 10^3$ ohm scale.

After calibration, both the remote and local meters indicated a dose rate of 0.5 mR/hr at the ante-room location of the replacement detector and the signal from the detector was recorded (see page A-43). The 10V supply measured 9.99V, the 600V supply measured 605V, and the checksource coil measured 14 ma current, when tested. The signal output was ranging from 0 to 9.9V when measured with a DVM with background dose rate conditions and similarly varied when the checksource was activated, but at a much faster rate which appeared as approximately an averaged 5V level.

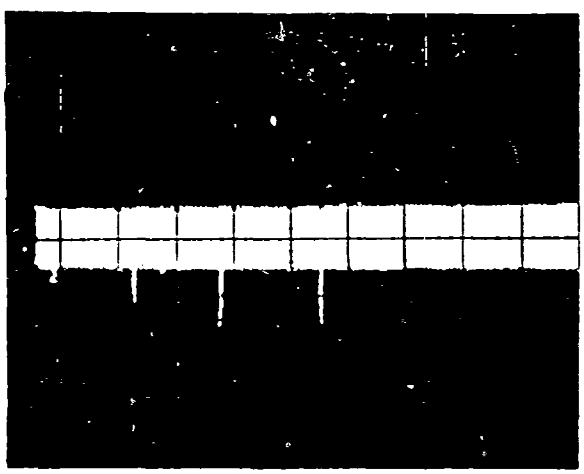
Time traces were taken of the output waveforms by photographing a storage oscilloscope trace. Figures 4-8 and 4-9 illustrate waveforms which exhibited the main differences between the original waveforms and the new ones (a complete set of plots are given on pages A-109 to A-115). Figure 4-8 shows the absence of the 120 Hz contamination on the 600V supply (which was also true for the checksource lines and the 10V supply). This improvement was probably the result of repairing the power supply capacitor in the readout module and is not indicative of the effect of replacing the detector. Figure 4-9 shows the pulsed voltage on the signal line, which has a significantly greater amplitude: 3.5V range previously and 9.9V with the new detector.

Both the high frequency and low frequency spectra taken on the signals show a continued low level contamination at both 16 and 20 kHz and harmonics; however, the magnitude is much lower than previously shown. The complete set of spectra are given in the Appendix on pages A-116 to A-121.



a) Vertical Scale
20 mV/Div

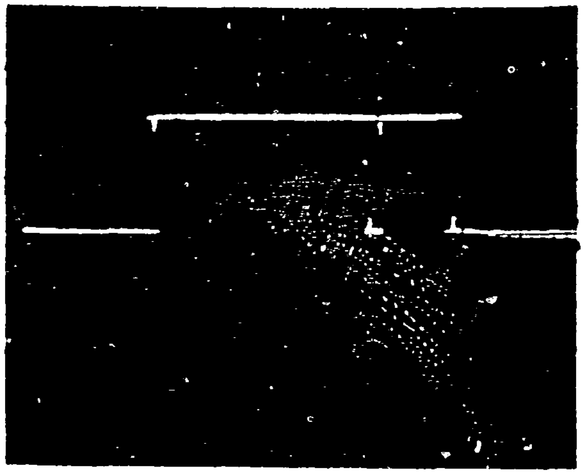
Horizontal Scale
10 mS/Div



b) Vertical Scale
100 mV/Div

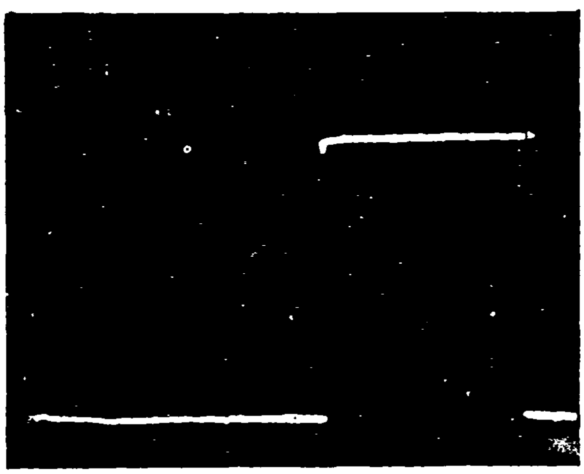
Horizontal Scale
0.2 Sec/Div

Figure 4.8 AC Fluctuations on 600V Supply After Replacement of Detector.



a) Vertical Scale
0.5 V/Div

Horizontal Scale
1 Sec/Div



b) Vertical Scale
0.2 V/Div

Horizontal Scale
0.5 Sec/Div

Figure 4.9 Fluctuation of SIGNAL OUT After Replacement of Detector.

## 4.5 MEASUREMENTS FOLLOWING ATTEMPTED DETECTOR REPLACEMENT IN CONTAINMENT

Following the testing of the detector installed in the ante-room, the containment monitor was to be replaced with the detector (serial # 111) which was just tested and calibrated. However, during the removal of the old detector, the connector to the detector was broken and insertion of the new detector was not possible. Dispute this problem, the old detector was removed for testing by Sandia Laboratory. Since there was no detector installed in the HP-R-211 circuit, the only measurements that would possibly provide any useful data were the TDR measurements on the cable. The results of these measurements are summarized in Table 4-5 and the strip chart traces are shown on pages A-123 to A-132.

Table 4-5

SUMMARY OF TDR INFLECTION POINTS FOR DAMAGED CABLE

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| Checksource | 168 | Increased R point | terminal block |
| | 247 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 379 | Large R increase | open circuit |
| +600V (RG59) | 179 | Increased R point | terminal block |
| | 179+ | Continuous R decrease | ? |
| | 274 | Increased R point | terminal block |
| | 374 | Slight continuous R decrease | ? |
| | 405 | Large R increase | open circuit |
| Signal (RG58) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 268 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 395 | Large R increase | open circuit |

Table 4-5 (Continued)

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| +10V | 163 | Increased R point | terminal block |
| | 245 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 384 | Large R increase | open circuit |

*TDR to terminal block test cable(s) (15 ft) not included in distance.

**R is the abbreviation for resistance.

# 5. DATA ANALYSIS

Following the actual field data gathering and on-site preliminary interpretations (given in Section 4), detailed analysis of the data was performed off-site. This data analysis consisted both of reducing the recorded data and interpretation of measurements to infer physical characteristics of the instrumentation.

## 5.1 REDUCTION OF RECORDED DATA

As described in the previous section, a recording was made of the detector output signals for three conditions:

1. Original HP-R-211 response
2. HP-R-211 response after electronic calibration
3. Replacement detector following complete calibration.

Examination of the waveforms from the original detector showed that there was a +6V offset on the signal with pulses rising to 9.5V and falling back to 6V also present. The operations manual for the detector indicates that the proper range of signals is approximately 0-10V (with a 0.8V possible variation due to electronics). This correct span of operation observed on the output of the replacement detector indicated that some problem existed in the detector or in the containment penetration (cable passing into containment). However, it is extremely unlikely that a cable problem would produce a signal with an offset and pulses correspondingly clipped at the offset value. Hence, the detector was selected as the most likely candidate for having failed (i.e., not producing its normal output response).

A more quantitative analysis of the detector recordings was also attempted because, as noted during field measurements, the pulse rate (but not the pulse height) from the original detector appeared to be consistent with believed containment radiation levels. A summary of the count rate for the three measurements is given in Table 5-1. Note that the operation of the device requires that two ionizing events occur to produce the "up" and "down" transition of the output. This is due to the "flip-flop" logic in the detector circuitry. Because the output wave forms were observed to be of improper range for the original detector, a pulse shaping circuit was applied to the reproduced signal to generate a proper indication of the detector response. The diagram for this circuit is shown in Figure 5-1.

The first amplifier stage was applied to remove any signal offset (AC coupled) and to convert the detector output into overloaded pulse events (saturation of maximum amplifier output at approximately 11V). This produces a well-defined range of the signal between -11V and +11V for processing by the threshold detector. Any delay introduced by the amplifier is not important since ionization events in the detector would be random, and hence not effected by such delays. Following the amplifier, a threshold detector circuit was inserted and adjusted to trigger at approximately +5V with a hysteresis of 5V. This produced an output of +9.2V when the detector signal exceeded 5V and maintained this output until the signal dropped below 0V, which triggered an 0V output. The range of 0 to 9.2V was chosen because this was the minimum range normally resultant from the detector circuit. (However, a test to determine the effect of this range was also performed later.)

Table 5-1

COUNT RATES MEASURED FROM SIGNAL RECORDINGS

| Description of Data | Average* Count Rate (CPS) | Average** Reading in mR/hr | Ratio of CPS/(mR/hr) |
|---|---|---|---|
| Original Detector as found) | 301(3)† | 200(3) | 1.51 |
| Original Detector (after electrical calibration | 293(4) | 103(5) | 1.52 |
| Replacement Detector (background) | 0.23(.08) | 0.29(.09) | 0.79 |
| Replacement Detector (checksource) | 7.2(0.5) | 5.2(0.1) | 1.38 |

*Actual detector ionization event rate is twice the listed value.

**From a readout module connected to a pulse shaping circuit applied to the reproduced signal with a 9.2V range.

†Numbers in parentheses are the associated standard deviations.

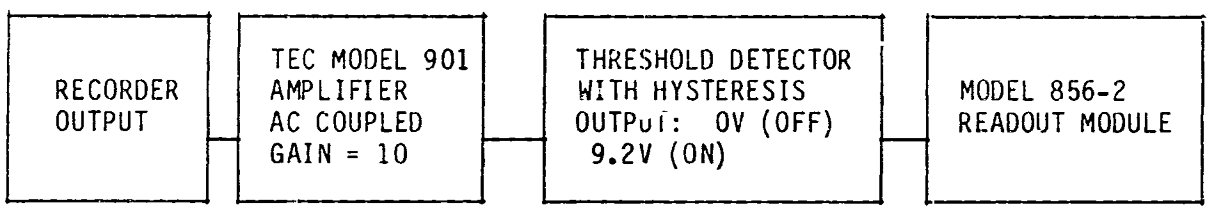



Figure 5-1. Diagram of Pulse Shaping Circuitry.

Referring to Table 5-1, the original detector count rates with the assumed pulse shaping are indicative of dose rates of approximately 200 mR/hr inside containment instead of 1.5 mR/hr as indicated on the control room readout. A review of the readout meter theory of operation shows why this extreme variation in indication occurs. The readout meter converts the detector signal transitions to logarithmic levels using a "log-pump" circuit. This circuit essentially consists of a series of capacitors (one for each decade range) which are charged by the maximum signal level and are then discharged through a resistor when the minimum signal level occurs. The resultant voltage output from the series of R-C circuits is summed to produce the readout value, with adjustments for "zero" and "span". Each R-C circuit (stage) is staggered by approximately a factor of ten in time response so that the more rapidly the input signal changes, the more stages reach near constant outputs and hence indicate higher radiation levels.

This entire circuit is dependent on the span of the input signal to generate the discharge levels from the capacitors through the resistors and is not sensitive to offset values due to the capacitive coupling. Since the range of the pulses was only 3.5 volts on the original detector, the readout module was not capable of interpreting the correct radiation levels. To understand the effect of various pulse ranges, a simple experiment was performed using a function generator, at various frequencies and output levels, acting as a "detector" input into a model 856-2 readout module. Figure 5-2 shows the results of this test. As expected from the log-pump circuit operating principles, at low signal ranges there is very little dependence of the meter on the input frequency (i.e., simulated

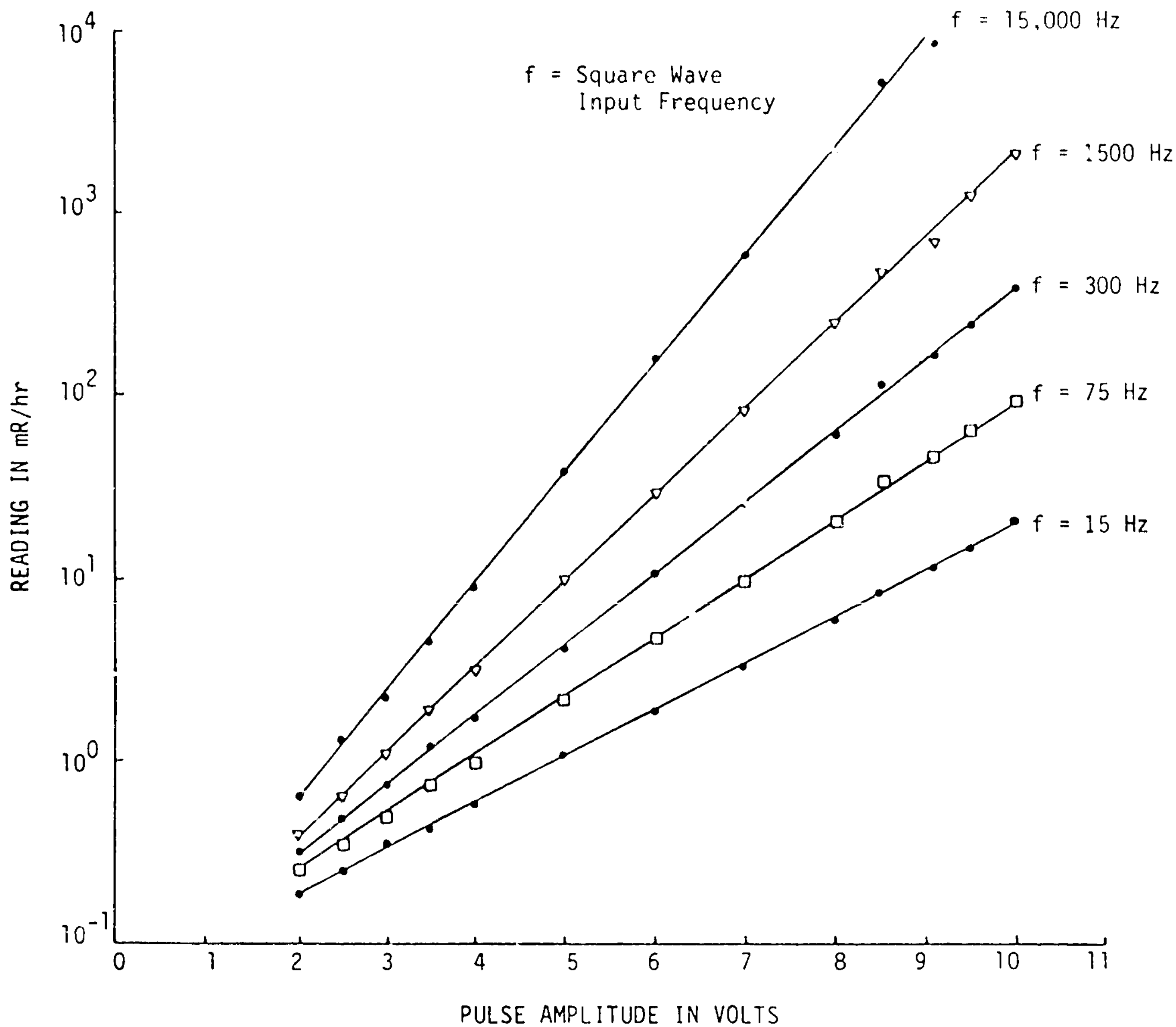



Figure 5-2 Victoreen Alarm/Rate Meter Response to Test Signals.

ionization events) due to the low charge/discharge levels in the circuit. This data sugggests that for the original detector with a 3.5V range, the response of the readout meter would not exceed 5 mR/hr event at full-scale radiation levels.

From Table 5-1 and Figure 5-2, there appears to be a near-constant conversion between pulse rate and readout indication at a fixed pulse voltage span with variations occurring at low radiation levels. This behavior is expected since the design of the system uses only the frequency of ionization events to generate an output (at a fixed pulse range). From the data gathered, this constant appears to be approximately 1.5 CPS/(mR/hr) which was also observed during mock-up testing (see page A-20). The variations in Table 5-1 for the replacement detector data are probably due to improper adjustments to the readout module, non-linearities at low readings, and difficulties in reading the meter at low values (needle variations). Note that the ratios of 1.55 and 1.51 are obtained for the replacement ratios in Table 5-1 if one standard deviation is added to the count rate and one standard deviation is subtracted from the dose rate. Thus the value of 1.5 CPS/(mR/hr) appears to be statistically acceptable as a count rate to dose rate conversion value.

For completeness in interpretation of this value, two other factors must be considered. Referring to Figure 5-2, a factor of 2 increase in response occurs if the output pulses of the detector change from 9.2V to 10V. Thus, if the meter were calibrated to expect pulses spanning 10 volts, the conversion value of 0.75 CPS/(mR/hr), or 1.33 (mR/hr)/CPS, is predicted.

The observations of a reading of 0.5 mR/hr background and of 9.9V pulse transitions during the measurements on the replacement detector suggest that this value is more nearly correct. With this conversion factor considered, the inferred dose rate indicated by HP-R-211 was 400 mR/hr inside containment. The second factor that needs to be emphasized is the fact that two ionization events must occur in the GM tube of the detector to achieve a complete pulse output. As mentioned previously, this is due to the "flip-flop" output conditioning of the detector in which each GM tube event triggers a change in state (i.e., ON to OFF or OFF to ON).

## 5.2 INTERPRETATION OF MEASUREMENTS

After acquiring the data and performing some analysis of the recorded data, HP-R-211 appeared to be non-functional (using the installed instrumentation) due to a reduced amplitude signal produced in the detector output circuitry. By comparing restored signal indications to expected dose rate levels, the remainder of the detector and the entire readout module appears to be operating correctly, at least within normal variations due to lack of recent calibration and some potential changes in the GM tube sensitivity.

As a result of these findings, an attempt to predict the problem in the detector was made based on comparisons of measurements obtained on the new detectors and on the HP-R-211 detector. Figure 2-4 shows the electrical circuit within the detector housing, and Tables 4-2 and 4-4 give the resistance measurements for the reference and original detectors, respectively. Note that the cable resistances are included in data from the original detector since it was installed inside containment; but any small resistances would not seriously change the results, and TDR measurements indicated no large cable resistances.

The only significant differences observed in the HP-R-211 data compared to the references were an increase in checksource resistance by 10 ohms, a low resistance path of only 305 ohms from signal in to +10V supply, and a small reduction in resistance between shield and +10V supply. The increase in the checksource resistance is within the expected variation in coil resistances and the added cable resistance and is not considered important. The extremely low resistance of 304 ohms between the signal line and the shield (ground) is probably responsible for the small reduction in the shield to +10V resistance, and therefore will not be considered separately unless analysis indicates otherwise.

Referring to the electrical circuit schematic in Figure 2-4, there are numerous paths between the signal line and the 10V supply, but only two main paths exist in the output section transistors Q6, Q7, and associated resistors. (The output section is considered the likely problem area due to indications of all other sections operating.) The first path consists of two fixed resistors R23 (10 k-ohm) and R21 (100 ohm), and the second path consists of Q6 (2N3906) and R20 (100 ohm). For the first path to produce a low resistance with a single failure, R23 would need to have a resistance of 200 ohms since R23 is normally much larger than the 304 ohms measured. However, the mechanism for such a reduction in resistance is not clear and, if R23 were reduced that low, normal operation of Q7 to pull the signal to ground would connect the +10V to ground through a 200 ohm resistance. If this occurred, the load on the 10V supply would have been 50 ma, which is much greater than the normal load, and would have produced variations in the 10V supply due to this excessive load. No extreme voltage variations were observed (see page A-84), which indicates this path was not responsible for the offset in the output.

The second path would require Q6 to have a 200 ohm short from emitter to collector (in the unpowered state) to produce the low resistance measurement. Since this path normally enables the HI output state (+10V) through a 100 ohm resistor, the loading on the signal line due to the readout module must be very low, and no variation on the 10V supply would be expected. Also, mechanisms for such a transistor failure are much more likely than for the resistor, R23, to have a reduction in resistance. This would also explain the reduction in the shield to 10V supply lines due to the formation of a 10.2 k-ohm path through resistor R22 if Q6 failed. As a result of this type of reasoning, along with analyses to determine alternate causes of the offset observed, it is felt that the cause of the offset present in the signal line is due to a low resistance path through Q6.

# 6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-211, the likely cause of the apparent failure of the monitor was a failure of transistor Q6 (see Figure 2.4). This resulted in a low resistance path between the 10V power supply and the signal, which held the Signal Out level within 3.5 volts of the power supply level, even when Q7 attempted to pull the level to ground.

Further analysis indicated that if the detector output signals were conditioned to their proper levels using external circuitry, a dose rate of approximately 400 mR/hr was indicated. Current results indicate that this circuitry would have been capable of restoring the proper signal if the Q6 failure progressed to fully open or shorted.

Other measurements indicated that with the exception of the failure of Q6 inside the detector housing, the HP-R-211 monitoring system was functioning properly.

# APPENDIX

## FIELD DATA SHEETS AND FIGURES

Included in this Appendix are the original field data sheets from the measurements which were left as originally filled out without corrections or alterations, except for some added comments. Also included is a complete set of photographs and strip chart results from the measurement program. Due to the separate measurements taken, this Appendix is divided into the following sections with starting page numbers given.

# SECTION A.1

## MOCK-UP MEASUREMENTS PRIOR TO FIELD TESTS

(with Figures)

REVIEW & PRE TEST COPY



| Technology for Energy Corporation | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 / REV. 0 |
| --- | --- | --- |
| PROCEDURE | APPROVED M.V. Mathis, Director, Tech. Serv. Div. | DATE 8-11-80 |

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El-305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

| Active Signal Parameter | Time Domain Reflectometry | Impedance |
|---|---|---|
| Voltage | 225 mV nominal (into 50 ohm base) | $\leq$ 5V rms |
| Frequency | --- | 100Hz, 1kHz, 10kHz, 100kHz |
| Current | $\leq$ 10mA | $\leq$ 100mA |
| Other | 225mV, 110 picosecond pulses | --- |

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).

2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.

3. Burns & Roe Dwg. 3024, Sh. 30A.

4. Burns & Roe Dwg. 3043, Sh. 16D.

5. Burns & Roe Dwg. 3045, Sh. 34.

6. Burns & Roe Dwg. 3045, Sh. 34B.

7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.

8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.

9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).

10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.

11. Instruction Manual, Tektronix Model 335 Oscilloscope.

12. Instruction Manual, Lockheed Store-4 Recorder.

13. Instruction Manual, Tektronix SC502 Oscilloscope.

14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| Signal | CABLE ~~Penetration~~ IT2931I | Cabinet 12 |
|---|---|---|
| +10V | | TB109-8 |
| 600V | | TB109-5 |
| SIG | | TB109-6 |
| GND | | TB109-10 |
| CS | | TB109-1 |
| CS | | TB109-2 |

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

Signature/Date

3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 856-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7 1/2 IPS DIRECT CHAN 1 DC COUPLED USING 465B AMP

GAIN = 50uV

| Meter/Indicator/Switch | Local | Rmte |
|---|---|---|
| mR/hr Meter Reading | ________ | ______ |
| Off-Operate-Alarm Function Switch | ________ | N/A |
| Fail Safe Indicator | On____Off____ | N/A |
| High Alarm-Reset Indicator | On____Off____ | N/A |

____________________
Signature/Date

4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fail-Safe Check Source push button during the measurement.

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

10 MIN

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 10.084<br>50uv p-p ~~60~~/25K<br>20uv p-p 60 |
| b. | TB109-6<br>TB109-10 | (+)<br>(-) | (SIG IN) ______ ______<br>CS OUT CS IN |
| *c. | TB109-5<br>TB109-~~10~~ 11 | (+)<br>(-) | (600V) ________ |
| **d. | TB109-1 (open field side)<br>TB109-1 (cabinet side) | (+)<br>(-) | (≤500 mA est.) _______ |

*Use electrostatic voltmeter
**Link closed after measurement

______________________
Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO ____ | PHOTO ____ | PHOTO ____ |
|---|---|---|---|---|---|
| a. | TB109-1<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| b. | TB109-2<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| * c. | TB109-5<br>TB109-10 | +600V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| d. | TB109-6<br>TB19-10 | SIG | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| e. | TB109-8<br>TB109-10 | +10V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |

45 MIN

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date ____________________

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 1 |
| b. | TB109-6<br>TB109-10 | SIG IN<br>GND | |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | |

30 MIN
TEKTRONIC 465B
~~0.5~~ 50 mV

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., space, RF bandwidth, RF ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|
| ~~PHOTO 1 mm~~ PHOTO #1 | 25kHz & Harmonics | | |

Signature/Date

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

30 MIN

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| *a. | TB109-5<br>TB109-10 | +600V<br>GND | |
| b. | TB109-6<br>TB109-10 | SIG IN<br>GND | |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 2 |

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

| Procedure Step | Before | After | Remarks |
|---|---|---|---|
| | | | |
| See attached instrument shop procedure data sheet. | | | |

Instrument Shop Procedure No. ________

Signature/Date

9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

Signature/Date

10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| TERMINAL | SIGNAL IDENT. |
|---|---|
| TB109-1 (Blue) | C.S. |
| TB109-2 (Orange) | C.S. |
| TB109-3 (White) | Rem. Meter |
| TB109-4 (Yellow) IT2933C | HI N.C. |
| TB109-5 (RG 59/U, 72 OHM) | 600V |
| TB109-6 (RG 58/U, 50 OHM) | SIG IN |
| TB109-7 (RG 58/U, 50 OHM) | Shield |
| TB109-8 (Red) | +10V |
| TB109-9 (Green) IT2933C | Alert N.C. |
| TB109-10 (Blk)<br>(RG 59/U, 72 OHM) | GND<br>Shield |

Signature/Date

11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|---|
| | | | REV. 0 |

| TEST POINT | FROM | | TO | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue | IT1869I | Orange |
| b. | IT1869I | RG 59/U Center | IT1869I | RG 59/U Shield |
| c. | IT1869I | RG 58/U Center | IT1869I | RG 58/U Shield |
| d. | IT1869I | Red | IT1869I | Black |
| e. | IT1869I | Black | IT1869I | TB109-10 |

Record the data required below:

Coil!

30 MIN

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| a. | (INDUCTOR 4.51 mH) | (INDUCTOR 4.45 mH) | (INDUCTOR 6.86 mH) | 30.2 Ω | 41.4 Ω | 4.25 kΩ |
| b. | 262 pF | 271 pF | 263 pF | 5.94 MΩ | 588 kΩ | 6.05 kΩ |
| c. | 4.2 nF | .62 nF | 361 pF | 2.86 kΩ | 2.86 kΩ | 2.35 kΩ |
| d. | 108 μF | 103 μF | INDUCTOR | 18.7 Ω | 11.1 Ω | 11.1 Ω |
| e. | INDUCTOR | INDUCTOR | INDUCTOR | 97.6 mΩ | 99.1 mΩ | 1.31 Ω |

Signature/Date

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

| Test Point | High R @ N ft. | Low R @ N ft. | Instrument Settings | | | Photo No. * |
|---|---|---|---|---|---|---|
| | | | Ampl | Range | Mult | |
| a. | | | | | | |
| b. | | | | | | |
| c. | | | | | | |
| d. | | | | | | |
| e. | | | | | | |

45MIN

*Utilize strip chart where available.

Signature/Date

13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|---|
| | | | REV. 0 |

Polarity From = + To = −  Polarity From = − To = +

| TEST POINT | FROM LINK | TO LINK | RESISTANCE | R |
|---|---|---|---|---|
| CS a. | TB109-1 | TB109-2 | 30.4 Ω | 30.4 Ω |
| b. | | TB109-5 | | |
| c. | | TB109-6 | | |
| d. | | TB109-7 | | |
| e. | | TB109-8 | | |
| f. | | TB109-10 | | |
| g. | TB109-2 | TB109-5 | | |
| h. | | TB109-6 | | |
| i. | | TB109-7 | | |
| j. | | TB109-8 | | |
| k. | | TB109-10 | | |
| l. | TB109-5 | TB109-6 | >20 MΩ | >20 MΩ |
| m. | | TB109-7 | | |
| n. | | TB109-8 | | |
| 600v o. | | TB109-10 | >20 MΩ | >20 MΩ |
| SIG p. | TB109-6 | TB109-7 | 8.85 kΩ | 7.23 kΩ |
| q. | | TB109-8 | | |
| r. | | TB109-10 | | |
| s. | TB109-7 | TB109-8 | | |
| t. | | TB109-10 | .68 Ω | .56 Ω |
| 10v u. | TB109-8 | TB109-10 | 11.9[illegible] kΩ | 7.47 kΩ |

45 MIN

Close all links on TB109 (opened in Step 10) when finished with this step.

Signature/Date

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm ~~Unit~~ (Ante-room). RECORD S/N OF DETECTOR USED

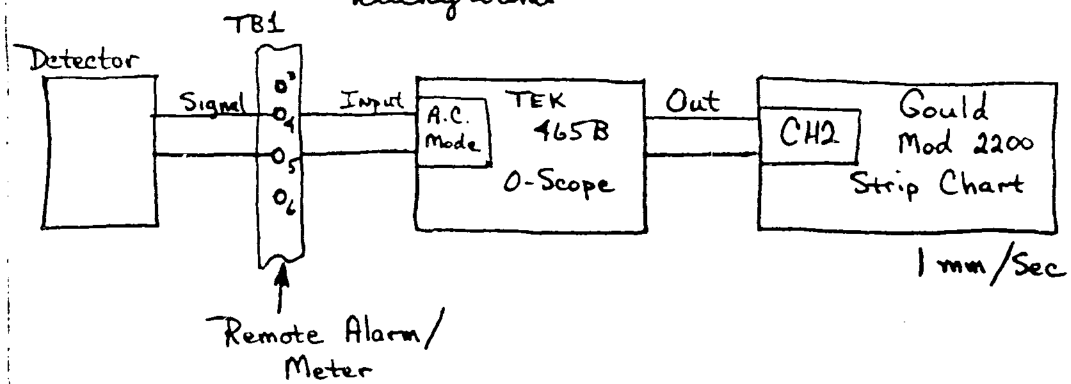
S/N

Signature/Date

TMI TESTS @ EG&G TRAILER

8/12/80 MV Mathis
JT Smith
JE Jones

① 17:04 Recording Pulses from Detector (10 MINUTE SPAN)
Background

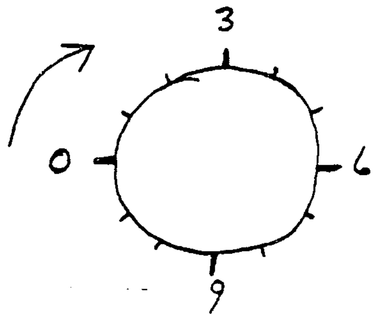



② 17:14 Recording Pulses with Check Source
Speed: 10 mm/Sec [See Figure Above]

— Performed TDR measurements of 10' test cable mock-up (see analysis sheet). Using Gould 2200 strip chart recorder at 5 mm/sec speed, a length calibration factor was obtained. This ~~fact~~ measurement yielded 19 full divisions on the strip chart corresponding to 10 divisions on the TDR display. Thus ft/division will be divided by 1.9 when recorded on strip charts.

JE Jones

CABLE DIELECTRIC SETTINGS




10' CALIBRATION VALUES (OPEN)

| CABLE PAIR | "OTHER" SETTING |
|---|---|
| Red - Black (#22) | 4.25 |
| Blue - Orange | 4.75 |

4.50 Value Selected!

MEASUREMENTS (10' LENGTH CABLE) [10' Test Cable & CLIPS USED]

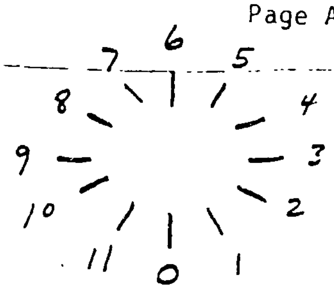
| CABLE PAIR | LENGTH (OPEN) | LENGTH (CLOSED) | DIELECTRIC |
|---|---|---|---|
| RED - BLACK (#22) | 10.25' | 10.1' | OTHER |
| RG58 | 10' | 10.1' | SOLID POLY |
| RG59 | 9.9' | 9.9' | SOLID POLY |
| BLUE - ORANGE | 9.9' | 10.0 | OTHER |
| BLACK - RG59 Shield | 9.85' | 10.05' | OTHER |
| BLUE - VIOLET | 9.9' | 10.0' | OTHER |

Due to above measurements, the "SOLID POLY" setting will be adequate for the RG58 & RG59 cables and the "OTHER" setting selected [at 4.5 relative value on potentiometer] for other cables.

8/12/80

J E Jones

VAR
POT




MOCK-UP DETECTOR CABLE

P calibrated for 10'

| Cable open | SET UP | | |
|---|---|---|---|
| Blue to org | OTHER | VAR | 6.25 |
| RG 59 | OTHER | VAR | 5.50 |
| RG 58 | OTHER | VAR | 5.50 |
| Red to BLK | OTHER | VAR | 6.00 |
| BLK To RG59 Shield | OTHER | VAR | 5.00 |

CABLE TERMINATED INTO DETECTOR

| | off of scale | from strip chart |
|---|---|---|
| Blue to Org. | 10.3' | 10.6' |
| RG 59 | 10.2' | 10.4' |
| RG 58 | 10.2' | 10.4' |
| Red to BLK | 11.0' | 11.2' |
| BLK to RG59 Shield | 10.85' | 10.8' |

G.M. Mueller results
8/11/80

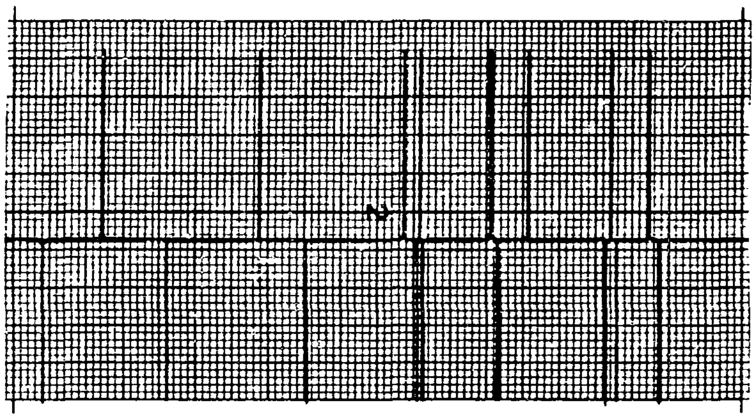
MOCK-UP TEST

Test in Trailer

(1) Background of Detector

Background Reading ∿ 0.2 mR/hr

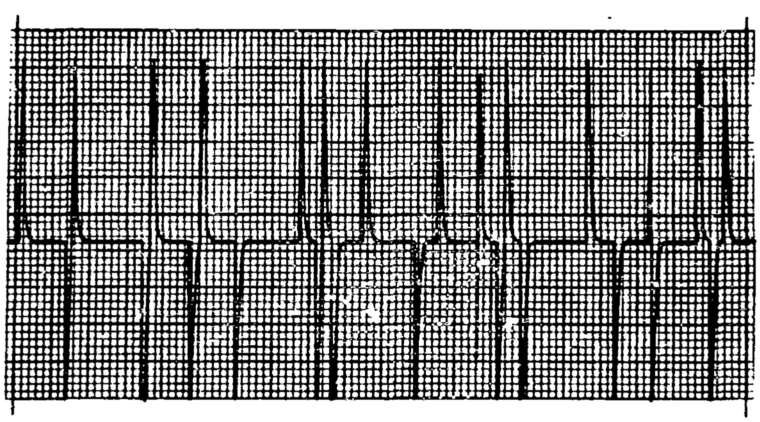
102 Counts/10 min.
Chart Speed: 1 mm/s



(Typical)

(2) Check Source in Detector

Check Source Reading ∿ 2 mR/hr
184 Counts/1 min.
Chart Speed 10mm/s

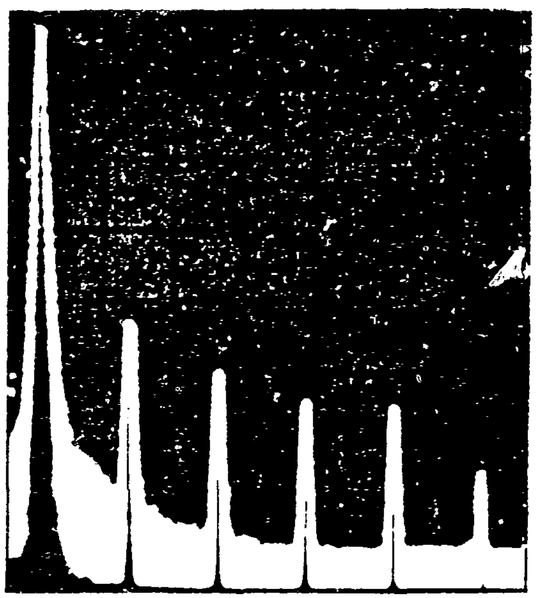


(Typical)

Mock-up Test (Trailer)

Low Frequency Spectrum

PHOTO #1



BW = 1KHz

Horiz. Scale: 20 KHz/Div
(0.1 s/Div Scan)

Vert. Scale: 10 dB/Div

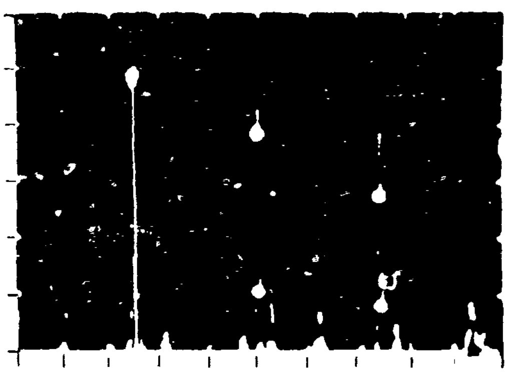
+10V Signal (AC Coupled)

Mock-up Test (Trailer)

Low Frequency Spectrum

0.0116 RMS

PHOTO #2



+10V Signal (AC Coupled)

Range: 0 - 100 KHz

20 KHz Harmonics Intensified

Vert. Scale: +10 dB Ref;
10 dB/Div

SECTION A.2

PRE-INSERTION DETECTOR PIN MEASUREMENTS

(Procedure pages used to record data)

| TEC | TITLE: IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|
| | | REV. 0 |

SERIAL #1405

Pre-Insertion Pin Measurements

| TEST POINT | FROM | | TO | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue | IT1869I | Orange |
| b. | IT1869I | RG 59/U Center | IT1869I | RG 59/U Shield |
| c. | IT1869I | RG 58/U Center | IT1869I | RG 58/U Shield |
| d. | IT1869I | Red | IT1869I | Black |
| e. | IT1869I | Black | IT1869I | TB109-10 |

Record the data required below:

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency → | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| a. | | | | | | |
| b. | -16 → +60pF | 24pF | 18.6pF | O.F. | 6.6MΩ | 720 kΩ |
| c. | 3.9nF | 0.30nF | 47pF | 2.93 kΩ | 2.93kΩ | 2.85 kΩ |
| d. | 108μF | 103μF | O.F. | 18.5Ω | 10.9Ω | 10.7Ω |
| e. | | | | | | |

J E Jones 8/14/80

Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

SERIAL #1405

(TEC#8032) Kiethly 177 DMM : 200 kΩ SCALE

PRE-INSERTION PIN MEASUREMENTS

| TEST POINT | + FROM LINK | − TO LINK | RESISTANCE Polarity + | − | 20K scale MBM 8-14-80 |
|---|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | 30Ω | 30Ω | |
| b. | | TB109-5 | ~ | ~ | |
| c. | | TB109-6 | ~ | ~ | |
| d. | | TB109-7 | ~ | ~ | |
| e. | | TB109-8 | ~ | ~ | |
| f. | | TB109-10 | ~ | ~ | |
| g. | TB109-2 | TB109-5 | ~ | ~ | |
| h. | | TB109-6 | ~ | ~ | |
| i. | | TB109-7 | ~ | ~ | |
| j. | | TB109-8 | ~ | ~ | |
| k. | | TB109-10 | ~ | ~ | |
| l. | TB109-5(E) | TB109-6 | ~ | ~ | |
| m. | | TB109-7 | ~ | ~ | |
| n. | | TB109-8 | ~ | ~ | |
| o. | | TB109-10 | ~ | ~ | |
| p. | TB109-6(G) | TB109-7 | 9.7kΩ | 9.7kΩ | 8.79 7.16 |
| q. | | TB109-8 | 9.7kΩ | 9.63kΩ | 8.78 6.84 |
| r. | | TB109-10 | 9.7kΩ | 9.7kΩ | |
| s. | TB109-7 | TB109-8 | 17.7kΩ | 17.7kΩ | 7.57 11.84 |
| t. | | TB109-10 | 0 | 0 | |
| u. | TB109-8 | TB109-10 | 17.7kΩ | 17.7kΩ | |

~ = OPEN

Note: TB109-7, TB109-10 are identical at detector

Close all links on TB109 (opened in Step 10) when finished with this step.

~~Ground~~ CASE : SHORTED To GROUND

J E Jones 8/14/80
Signature/Date

~~PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).~~

Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

SERIAL #111

(TEC #8032) Kiethly 177 DMM : 20 kΩ SCALE

PRE-INSERTION PIN MEASUREMENTS

Note: {TB109-7 {TB109-10 are identical at detector

| TEST POINT | FROM LINK | TO LINK | RESISTANCE Polarity + | − |
|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | | |
| b. | | TB109-5 | | |
| c. | | TB109-6 | | |
| d. | | TB109-7 | | |
| e. | | TB109-8 | | |
| f. | | TB109-10 | | |
| g. | TB109-2 | TB109-5 | | |
| h. | | TB109-6 | | |
| i. | | TB109-7 | | |
| j. | | TB109-8 | | |
| k. | | TB109-10 | | |
| l. | TB109-5 | TB109-6 | | |
| m. | | TB109-7 | | |
| n. | | TB109-8 | | |
| o. | | TB109-10 | | |
| p. | TB109-6 | TB109-7 | 8.77kΩ | 7.34kΩ |
| q. | | TB109-8 | 8.27kΩ | 6.56kΩ |
| r. | | TB109-10 | 8.77kΩ | 7.34kΩ |
| s. | TB109-7 | TB109-8 | 7.44kΩ | 11.77kΩ |
| t. | | TB109-10 | 0 | 0 |
| u. | TB109-8 | TB109-10 | 11.77kΩ | 7.44kΩ |

Close all links on TB109 (opened in Step 10) when finished with this step.

Jeff Mueller 8/15/80
Signature/Date
JEJ

14. ~~PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).~~

Signature/Date

# SECTION A.3

## PROCEDURES FOR PRE-REMOVAL AND POST-REMOVAL MEASUREMENTS

| Technology for Energy Corporation | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|
| | | REV. 0 |
| PROCEDURE | APPROVED M.V. Mathis, Director, Tech. Serv. Div. | DATE 8-11-80 |

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El. 305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

| Active Signal Parameter | Time Domain Reflectometry | Impedance |
|---|---|---|
| Voltage | 225 mV nominal (into 50 ohm base) | $\leq$ 5V rms |
| Frequency | --- | 100Hz, 1kHz, 10kHz, 100kHz |
| Current | $\leq$ 10mA | $\leq$ 100mA |
| Other | 225mV, 110 picosecond pulses | --- |

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).
2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
3. Burns & Roe Dwg. 3024, Sh. 30A.
4. Burns & Roe Dwg. 3043, Sh. 16D.
5. Burns & Roe Dwg. 3045, Sh. 34.
6. Burns & Roe Dwg. 3045, Sh. 34B.
7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).
10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
11. Instruction Manual, Tektronix Model 335 Oscilloscope.
12. Instruction Manual, Lockheed Store-4 Recorder.
13. Instruction Manual, Tektronix SC502 Oscilloscope.
14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| Signal | Cable ~~Penetration~~ IT2931I | Cabinet 12 |
|---|---|---|
| +10V | | TB109-8 |
| 600V | | TB109-5 |
| SIG | | TB109-6 |
| GND | | TB109-10 |
| CS | | TB109-1 |
| CS | | TB109-2 |

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

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3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 8~~2~~56-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7½ IPS DIRECT (CHAN 1)
DC COUPLED THRU 465B AMPLIFIER — No! +8V offset required AC coupling.
G=50mV & CALIBRATED

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

| Meter/Indicator/Switch | Local | Rmte |
|---|---|---|
| ~~Mr~~ mR/hr Meter Reading | 1.5 mR | 3.5 mR |
| Off-Operate-Alarm Function Switch | OPERATE | N/A |
| Fail Safe Indicator | On ✓ Off ___ | N/A |
| High Alarm-Reset Indicator | On ___ Off ✓ | N/A |

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4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fail-Safe Check Source push button during the measurement.

| TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 9.4V |
| b. | TB109-6<br>TB109-~~10~~ 7 | (+)<br>(-) | (SIG IN) 7.5V CS OUT 7.5V CS IN |
| *c. | TB109-5<br>TB109-~~10~~ 10 | (+)<br>(-) | (600V) 605V |
| **d. | TB109-1 (open field side)<br>TB109-1 (cabinet side) | (+)<br>(-) | (≤500 mA est.) -13 mA<br>Note: Last Calibration 2/78. |

*Use electrostatic voltmeter
**Link closed after measurement

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| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO 3 | PHOTO 4 | PHOTO 5 |
|---|---|---|---|---|---|
| ✓a. | TB109-1<br>TB109-10 | CS | Time Base 5mSec<br>Vert Gain 2V | 2 mSec<br>1V | 1mSec<br>1V |
| | | | PHOTO 6 | PHOTO 7 | PHOTO 8 |
| ✓b. | TB109-2<br>TB109-10 | CS | Time Base 5mSec<br>Vert Gain 2V | 2 mSec<br>1V | 1mSec<br>1V |
| | | | PHOTO 9 | PHOTO 10 | PHOTO 11 |
| ✓*c. | TB109-5<br>TB109-10 | +600V | Time Base 5mSec<br>Vert Gain .2V | 2mSec<br>.2V | 10mSec<br>.2V |
| | | | PHOTO 12 | PHOTO 13 | PHOTO 14 |
| ✓d. | TB109-6<br>TB19-~~10~~ 7 | SIG | Time Base 1mSec<br>Vert Gain 1V | 2mSec<br>1V | 2mSec<br>2V |
| | | | PHOTO 15 | PHOTO 16 | PHOTO 17 |
| ✓e. | TB109-8<br>TB109-10 | +10V | Time Base 2mSec<br>Vert Gain 2V | 5mSec<br>1V | 2mSec<br>.5V |
| | | | PHOTO 18 | PHOTO 19 | PHOTO 20 |
| *f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base 10mSec<br>Vert Gain 2mV | 20mSec<br>1mV | .2mSec<br>1mV |
| | | | 21<br>Time: 10μSec<br>Gain: 10mV | 22<br>Time: 50μSec<br>Gain: 10mV | 23<br>Time: 2mSec<br>Gain: 5mV |

Note: Fuse on 110V Blown... Repeat Tests

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

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TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 24, 25 |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 26 |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | 27 |

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., ~~[illegible]~~ RF bandwidth, RF ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|
| #24 | 0 - 1.4 MHz | ~ | Low Range Noise |
| #25 | 0 - 3.5 MHz | ~ | Low Range Noise |
| #26 | 0 - 3.5 MHz | ~ | Low Range Noise |
| #27 | 0 - 3.5 MHz | ~ | Very Low Noise |

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| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 / REV. 0 |
|---|---|---|---|

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # | REMARKS |
|---|---|---|---|---|
| *a. | TB109-5<br>TB109-10 | +600V<br>GND | 28 | 20 kHz & Harmonics Peaks |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 29 | Dominantly 1/f Noise ~32kHz Harmonics |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 30,31 | Peaks at 16kHz & 20 kHz Harmonic<br>120 Hz Harmonics |

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

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8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

see copy of shop procedure following

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

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| Procedure Step | Before | After | Remarks |
|---|---|---|---|
| ——— | ——— | ——— | LAST CALIBRATION 2/78 |
| See Attachment Pages 1A & 1B | | | |
| Major Change: +22V unregulated P.S. was @ +13.7V. Capacitor replaced ⇒ 20.2V & +10V adjusted downward since it comes from +22V line. | | | |
| See attached instrument shop procedure data sheet. | | | |

Instrument Shop Procedure No. ________

8/13/80
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9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

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Signature/Date

10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

| TERMINAL | SIGNAL IDENT. |
|---|---|
| TB109-1 (Blue) | C.S. |
| TB109-2 (Orange) | C.S. |
| TB109-3 (White) | Rem. Meter |
| TB109-4 (Yellow) IT2933C | HI N.C. |
| TB109-5 (RG 59/U, 72 OHM) | 600V |
| TB109-6 (RG 58/U, 50 OHM) | SIG IN |
| TB109-7 (RG 58/U, 50 OHM) | Shield (Signal) |
| TB109-8 (Red) | +10V |
| TB109-9 (Green) IT2933C | Alert N.C. |
| TB109-10 (Blk) (RG 59/U, 72 OHM) | GND Shield |

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11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| TEST POINT | FROM * (Red Lead) | | TO * (Black Lead) | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue (TB109-1) | IT1869I | Orange (TB109-2) |
| b. | IT1869I | RG 59/U Center (-5) | IT1869I | RG 59/U Shield (-10) |
| c. | IT1869I | RG 58/U Center (-6) | IT1869I | RG 58/U Shield (-7) |
| d. | IT1869I | Red (-8) | IT1869I | Black (-10) |
| e. | IT1869I | Black (-10) | IT1869I | TB109-10 |
| f. | IT1869I | RG 58/U Shield | IT1869I | RG 58/U Center |

* Values in parenthesis refer to normal TB connection position.

Record the data required below:

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| (COIL) a. | O.F. | -5.77µF | -3.26 nF | 40.4Ω | 49.1Ω | 436 Ω |
| b. | -50 nF | 5 nF | 10 nF | O.F.* | O.F.* | 654 Ω |
| c. | O.F. | 90 nF | 12 nF | U.F. | 570Ω | 116 Ω |
| d. | O.F. | 20µF | -40nF | U.F. | 25Ω | 48.7Ω |
| e. | -6 → 9 mF | -382µF | -56nF | 400-1900 mΩ | 924 mΩ | 28.6 Ω |
| f. | ERR4 | ERR4 | 12nF | ERR4 | ERR4 | 116 Ω |

reverse polarity

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O.F. = overflow ; U.F. = underflow

* intermittant kΩ reading?

ERR4 = open or shorted; or DC bias won't work

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

| Test Point | High R @ N ft. | Low R @ N ft. | Instrument Settings Ampl | Range | Mult | Strip Chart ~~Photo~~ No. * |
|---|---|---|---|---|---|---|
| a. | | | 500 | 100'/Div | 1 | 12a-1, -2 |
| b. | | | | | | 12b-1, -2 |
| c. | | | | | | 12c-1, -2 |
| d. | | | | | | 12d-1, -2 |
| e. | | | | | | 12e-1, -2 |

*Uti'·ze strip chart where available.

Repeat c. With Terminal Block + 10' COAX → f. 12f-1, -2

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13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

~~NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.~~ NO.

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| | TEST POINT | FROM LINK | TO LINK | RESISTANCE<br>POLARITY<br>From = +<br>To = − | RESISTANCE<br>POLARITY<br>From = −<br>To = + |
|---|---|---|---|---|---|
| | a. | TB109-1 | TB109-2 | 40.2 Ω | 40.2 Ω |
| | b. | | TB109-5 | >20 megaΩ | >20 megaΩ |
| | c. | | TB109-6 | >20 megaΩ | >20 megaΩ |
| | d. | | TB109-7 | >20 megaΩ | >20 megaΩ |
| | e. | | TB109-8 | >20 megaΩ | >20 megaΩ |
| | f. | | TB109-10 | >20 megaΩ | >20 megaΩ |
| | g. | TB109-2 | TB109-5 | >20 megaΩ | >20 megaΩ |
| | h. | | TB109-6 | >20 megaΩ | >20 megaΩ |
| | i. | | TB109-7 | >20 megaΩ | >20 megaΩ |
| | j. | | TB109-8 | >20 megaΩ | >20 megaΩ |
| | k. | | TB109-10 | >20 megaΩ | >20 megaΩ |
| | l. | TB109-5 | TB109-6 | >20 megaΩ | >20 megaΩ |
| | m. | | TB109-7 | >20 megaΩ | >20 megaΩ |
| | n. | | TB109-8 | >20 megaΩ | >20 megaΩ |
| | o. | | TB109-10 | >20 MΩ | >20 megaΩ |
| Scale = 20K | p. | TB109-6 | TB109-7 | 8.62 kΩ | 6.53 kΩ |
| 2K | q. | | TB109-8 | 305 Ω | 305 Ω |
| 20K | r. | | TB109-10 | 10.0 kΩ | 10.0 kΩ |
| 20K | s. | TB109-7 | TB109-8 | 6.97 kΩ | 8.59 kΩ |
| 2K [illegible] 200Ω | t. | | TB109-10 | 1.96 Ω | 1.96 Ω |
| 20K | u. | TB109-8 | TB109-10 | 8.6 kΩ | 6.47 Ω |

Close all links on TB109 (opened in Step 10) when finished with this step.

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† links closed on TB109-1 through 9

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm ~~####~~ (Ante-room). RECORD S/N OF DETECTOR USED.

★ replaced detector

~~[illegible]~~ 111
S/N

[signature] 8/14/80
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| TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|

15. PRE-REMOVAL ONLY: Apply power to HP-RT-0211. After a minimum of 30 minutes warm up time perform ~~electronic~~ calibrations in accordance with applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

| PROCEDURE STEP | BEFORE | AFTER | REMARKS |
|---|---|---|---|
| | | | |

ELECTRONIC CALIBRATION NOT NEEDED -- PERFORMED IN STEP 8 & NO CHANGES HAVE OCCURRED.

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16. PRE-REMOVAL ONLY: Utilizing the Victoreen field calibration source perform calibration with source decay corrections in accordance with applicable Instrument Shop Procedures.

See copy of shop procedure following.

Instrument Shop Procedure No.

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| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|---|
| | | | REV. 0 |

17. Repeat Step 3. PRE-REMOVAL ONLY

| | LOCAL | RMTE |
|---|---|---|
| ~~MR~~ mR/Hr Meter Reading | .5 mR/hr | .5 mR/hr |
| Off-Operate-Alarm Function Switch | OP | N/A |
| Fail Safe Indicator | On ✓ Off __ | N/A |
| High Alarm-Reset Indicator | On __ Off ✓ | N/A |

~~&~~ RECORD (SEE STEP 3, P. 4) 15 MINUTES BACKGROUND, THEN REFER TO LOGBOOK

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18. Repeat Step 4. PRE-REMOVAL ONLY

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 9.99V |
| b. | TB109-6<br>TB109-~~10~~ 7 | (+)<br>(-) | (SIG IN) 0-9.88V (CS OUT) 5.0V (CS IN) |
| *c. | TB109-5<br>TB109-~~10~~ 70 | (+)<br>(-) | (600V) 605 |
| **d. | TB109-1 (Open-Field Side)<br>TB109-1 (Cabinet Side) | (+)<br>(-) | (≤500 ~~MA~~ mA est.) -14.1 |

*Use electrostatic voltmeter
**Link closed after measurement

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TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

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19. Repeat Step 5. PRE-REMOVAL ONLY

| SIGNAL | CABINET 12 | PARAMETER | PHOTO ~~32~~ 35 | PHOTO 36 | PHOTO 37 |
|---|---|---|---|---|---|
| ✓ a. | TB109-1<br>TB109-10 | CS | Time Base 5 mSec<br>Vert Gain .2V | 2 mSec<br>50 mV | 50 μSec<br>50 mV |
| | | | PHOTO 38 | PHOTO 39 | PHOTO 40 |
| ✓ b. | TB109-2<br>TB109-10 | CS | Time Base 10 mSec<br>Vert Gain 50mV | 2 mSec<br>50 mV | 50 μSec<br>20 mV |
| | | | PHOTO 41 | PHOTO 42 | PHOTO 43 |
| ✓ *c. | TB109-5<br>TB109-10 | +600V | Time Base 10 mSec<br>Vert Gain 20mV | .2 Sec<br>100 mV | 20 m Sec<br>100 mV |
| | | | PHOTO 32 | PHOTO 33 | PHOTO 34 |
| ✓ d. | TB109-6<br>TB19-~~10~~ 7 | SIG | Time Base 1 Sec<br>Vert Gain .5V | .2 Sec<br>.5 V | .5 Sec<br>.2 V |
| | | | PHOTO 44 | PHOTO 45 | PHOTO 46 |
| ✓ e. | TB109-8<br>TB109-10 | +10V | Time Base .1 mSec<br>Vert Gain 20mV | 5 m Sec<br>50 mV | .2 mSec<br>20 mV |
| | | | PHOTO 47 | PHOTO 48 | PHOTO 49 |
| ✓ f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base .2mSec<br>Vert Gain 5mV | .2m Sec<br>2mV | 50 μSec<br>2 mV |

* Use x 10 Probe

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20. Repeat Step 6. PRE-REMOVAL ONLY

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 50 |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 51 |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | 52 ~~53~~ |

* CAUTION: DECOUPLE.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|

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TEC TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

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21. Repeat Step 7. PRE-REMOVAL ONLY

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| ✓* a. | TB109-5<br>TB109-10 | +600V<br>GND | 53 |
| ✓ b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 54 |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 55 |

*DECOUPLE

Signature/Date

22. Repeat Step 9. PRE-REMOVAL ONLY

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23. PRE-REMOVAL ONLY: Remove interface cable connected in Step 14 and re-connect apprpriate field terminals to TB1 of the Remote Meter/Alarm Unit (Ante-room).

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24. PRE-REMOVAL ONLY: Reapply power by closing links opened in Step 22. Verify unit is operating as before by comparing meter readings with those taken in Step ~~6~~ 8.

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

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25. Repeat Step 3 at least 1 hour prior to entry for removal of HP-RT-0211. RECORDER MUST BE STARTED NO EARLIER THAN 1 HOUR BEFORE ENTRY...POWER LINKS SHOULD BE OPENED FOR REPLACEMENT OF DETECTOR THEN CLOSED.

ALL SUBSEQUENT STEPS ARE FOR POST REMOVAL MEASUREMENTS.

26. POST-REMOVAL ONLY. Repeat Step 3: (P 23)

Signature/Date

27. POST-REMOVAL ONLY. Repeat Step 4: (P 24)

Signature/Date

28. POST-REMOVAL ONLY. Repeat Step 5: (P 26)

Signature/Date

29. POST-REMOVAL ONLY. Repeat Step 6: (P 27)

Signature/Date

30. POST-REMOVAL ONLY. Repeat Step 7: (P 28)

Signature/Date

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

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(p 29)

31. <u>POST-REMOVAL ONLY</u>. Repeat Step 9. (Do Not Do Step 8).

Signature/Date

32. <u>POST-REMOVAL ONLY</u>. Repeat Step 10. (p 29)

Signature/Date

33. <u>POST-REMOVAL ONLY</u>. Repeat Step 11. (p. 30)

Signature/Date

34. <u>POST-REMOVAL ONLY</u>. Repeat Step 12. (p. 32)

Signature/Date

35. <u>POST-REMOVAL ONLY</u>. Repeat Step 13. (p. 32)

Signature/Date

36. <u>POST-REMOVAL ONLY</u>. Apply power to HP-RT-0211 and verify proper operation utilizing applicable instrument shop procedures.

Signature/Date

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

I hereby certify that this Test Procedure has been completed as written and that all data has been correctly entered and filed as requested.

TEC Representative ____________________
Signature/Date

Instrumentation ____________________
Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| Signal | Penetration IT2931I | Cabinet 12 |
|---|---|---|
| +10V | | TB109-8 |
| 600V | | TB109-5 |
| SIG | | TB109-6 |
| GND | | TB109-10 |
| CS | | TB109-1 |
| CS | | TB109-2 |

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

~~1.~~ PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

~~2.~~ PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

Signature/Date

(26) 3. ~~PRE-REMOVAL~~, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 856-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7½ IPS Direct (Chan 1)
DC Coupled Thru 465B Amplifier
G = 50mV Calibrated

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

| Meter/Indicator/Switch | Local | Rmte |
|---|---|---|
| ~~Mr~~ mR/hr Meter Reading | ________ | ________ |
| Off-Operate-Alarm Function Switch | ________ | N/A |
| Fail Safe Indicator | On____Off____ | N/A |
| High Alarm-Reset Indicator | On____Off____ | N/A |

______________________
Signature/Date

(27) 4. ~~PRE-REMOVAL~~ POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = ± 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fail-Safe Check Source push button during the measurement.

| TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) ______ |
| b. | TB109-6<br>TB109-~~10~~ 7 | (+)<br>(-) | (SIG IN) ______ ______<br>CS OUT CS IN |
| *c. | TB109-5<br>TB109-~~10~~ 10 | (+)<br>(-) | (600V) ______ |
| **d. | TB109-1 (open field side)<br>TB109-1 (cabinet side) | (+)<br>(-) | (≤500 mA est.) ______ |

*Use electrostatic voltmeter
**Link closed after measurement

______
Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

(28) 5. ~~PRE-REMOVAL~~ POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO ____ | PHOTO ____ | PHOTO ____ |
|---|---|---|---|---|---|
| a. | TB109-1<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| b. | TB109-2<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| *c. | TB109-5<br>TB109-10 | +600V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| d. | TB109-6<br>TB19-~~10~~7 | SIG | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| e. | TB109-8<br>TB109-10 | +10V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

(29) 6. ~~PRE-REMOVAL~~, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | ______ |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | ______ |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | ______ |

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., ~~[illegible]~~, RF bandwidth, RF ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|

Signature/Date

TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

(30) 7. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| *a. | TB109-5<br>TB109-10 | +600V<br>GND | |
| b. | TB109-6<br>TB109-~~10~~7 | SIG IN<br>GND | |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | |

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

Signature/Date

~~8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:~~

| Procedure Step | Before | After | Remarks |
|---|---|---|---|
| | | | |
| See attached instrument shop procedure data sheet. | | | |

Instrument Shop Procedure No. ________

________________
Signature/Date

(31) 9. ~~PRE-REMOVAL~~, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

________________
Signature/Date

(32) 10. ~~PRE-REMOVAL~~, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

| TERMINAL | SIGNAL IDENT. |
|---|---|
| TB109-1 (Blue) | C.S. |
| TB109-2 (Orange) | C.S. |
| TB109-3 (White) | Rem. Meter |
| TB109-4 (Yellow) IT2933C | HI N.C. |
| TB109-5 (RG 59/U, 72 OHM) | 600V |
| TB109-6 (RG 58/U, 50 OHM) | SIG IN |
| TB109-7 (RG 58/U, 50 OHM) | Shield (Signal) |
| TB109-8 (Red) | +10V |
| TB109-9 (Green) IT2933C | Alert N.C. |
| TB109-10 (Blk) (RG 59/U, 72 OHM) | GND Shield |

Signature/Date

(33) 11. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| TEST POINT | FROM | | TO | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue | IT1869I | Orange |
| b. | IT1869I | RG 59/U Center | IT1869I | RG 59/U Shield |
| c. | IT1869I | RG 58/U Center | IT1869I | RG 58/U Shield |
| d. | IT1869I | Red | IT1869I | Black |
| e. | IT1869I | Black | IT1869I | TB109-10 |

Record the data required below:

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency → | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| (Con) a. | | | | | | |
| b. | | | | | | |
| c. | | | | | | |
| d. | | | | | | |
| e. | | | | | | |

Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

(34) 12. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

| Test Point | High R @ N ft. | Low R @ N ft. | Instrument Settings<br>Ampl Range Mult | Photo No. * |
|---|---|---|---|---|
| ✓✓ a. | | | | [illegible] |
| ✓✓ b. | | | | [illegible] |
| ✓✓ c. | | | | [illegible] |
| ✓✓ d. | | | | [illegible] |
| ✓✓ e. | | | | [illegible] |

*Utilize strip chart where available.

[signature] 8/15/80
Signature/Date

(35) 13. ~~PRE-REMOVAL~~, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| TEST POINT | FROM LINK | TO LINK | RESISTANCE (POLARITY From = + To = −) | RESISTANCE (POLARITY From = − To = +) |
|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | | |
| b. | | TB109-5 | | |
| c. | | TB109-6 | | |
| d. | | TB109-7 | | |
| e. | | TB109-8 | | |
| f. | | TB109-10 | | |
| g. | TB109-2 | TB109-5 | | |
| h. | | TB109-6 | | |
| i. | | TB109-7 | | |
| j. | | TB109-8 | | |
| k. | | TB109-10 | | |
| l. | TB109-5 | TB109-6 | | |
| m. | | TB109-7 | | |
| n. | | TB109-8 | | |
| o. | | TB109-10 | | |
| p. | TB109-6 | TB109-7 | | |
| q. | | TB109-8 | | |
| r. | | TB109-10 | | |
| s. | TB109-7 | TB109-8 | | |
| t. | | TB109-10 | | |
| u. | TB109-8 | TB109-10 | | |

Close all links on TB109 (opened in Step 10) when finished with this step.

Signature/Date

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).

Signature/Date

# SECTION A.4

## DATA SHEETS FROM TMI TECHNICIAN CALIBRATIONS

DETECTER

Model
Serial

RATEMETER

Model 856-2
Serial 359

| FCK Posit. | Desired Mr./Hr. | As Found | As Left | Toler. |
|---|---|---|---|---|
| Closed | | | | |
| Iter. | | | | |
| Open | | | | |

Check Source Rdg._______Mr/Hr

Fail Safe________Volts

Ratemeter

| Input, DC | Mr/Hr | Desired Mv. Out | As Found | As Left | Toler. |
|---|---|---|---|---|---|
| 6.34 | $10^4$ | 1.00V | 1.005 | 1.000 | ±.03 v |
| | $10^3$ | .800V | .811 | .806 | ±.03 v |
| | $10^2$ | .600V | .612 | .607 | ±.03 v |
| | 10 | .400V | .415 | .411 | ±.03 v |
| 5.84 | 1 | .200V | .217 | .215 | ±.03 v |
| | .1 | .000 | .024 | .024 | ±.03 v |

| Pwr. Supply | As Found | As Left | Toler. |
|---|---|---|---|
| -6.8V | ~~-6.800~~ -6.85 | -6.84 | ±.5V |
| 10.0V | ~~9.31~~ 10.45 | ~~10?~~ 10.00 | ±.1V |
| 22.0V | ~~13.66~~ 20.20 | 20.20 | ±3.0V |

| Alarm Set. Pt. | As Found | As Left | Toler. |
|---|---|---|---|
| | | | ±1 Minor Division |

EQUIP. DIGITEC SER.NO. 61260552 LAST CAL. 3-20-80 DUE 9-20-80

EQUIP. FLUKE DVM SER.NO. 530314 LAST CAL. 7-25-80 DUE 1-25-81

EQUIP.________ SER.NO.________ LAST CAL.________ DUE________

PERFORMED BY Ed. Heffner DATE 8-13-80 APPROVED BY [signature] DATE 8/14/80



Section________

DETECTER

Model__________
Serial__________

RATEMETER

Model 856-2
Serial 359

| FCK Posit. | Desired Mr./Hr. | As Found | As Left | Toler. |
|---|---|---|---|---|
| Closed | | | | |
| Iter. | | | | |
| Open | | | | |

Check Source Rdg._______Mr/Hr

Fail Safe_______Volts

Ratemeter

| DIGITEC INPUT VOLTS DC | Mr/Hr | Desired Mv. Out | As Found | As Left | Toler. |
|---|---|---|---|---|---|
| 6.39 | $10^4$ | 1.00V | .999 | .999 | ±.03 v |
| 21 | $10^3$ | .800V | .807 | .807 | ±.03 v |
| 16.18 | $10^2$ | .600V | .611 | .611 | ±.03 v |
| 11.20 | 10 | .400V | .415 | .415 | ±.03 v |
| 6.13 | 1 | .200V | .218 | .218 | ±.03 v |
| .95 | .1 | .000V | .024 | .024 | ±.03 v |

(AFTER CHANGING C-1 in Ratemeter)

| Pwr. Supply | As Found | As Left | Toler. |
|---|---|---|---|
| -6.8V | -6.85 | -6.85 | ±.5V |
| 10.0V | +10.99 ~~+9.92~~ | +10.00 | ±.1V |
| 22.0V | 20.20 | 20.20 | ±3.0V |

| Alarm Set. Pt. | As Found | As Left | Toler. |
|---|---|---|---|
| | | | ±1 Minor Division |

EQUIP. DIGITEC SER.NO. 61260552 LAST CAL. 3-20-80 DUE 9-20-80

EQUIP. FLUKE DVM SER.NO 530314 LAST CAL. 7-25-80 DUE 1-25-81

EQUIP.________ SER.NO.________ LAST CAL.________ DUE________

PERFORMED BY Ed. Heffner DATE 8-14-80 APPROVED BY [signature] DATE 8/18

DATA S. _T 1
RADIATION MONITORING SYSTEM

| Procedure Step | | | | | | |
|---|---|---|---|---|---|---|
| 6.1.1.2 | MONITOR | HP-R- 211 | LOCAL METER | AS FOUND | AS LEFT | RECORDER TRACE MARKED YES/NO INT |

| | | FCK SOURCE KNOB POSITION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLOSED | | | | INTERMEDIATE | | | | OPEN | | | |
| | DESCRIPTION | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT |
| 6.1.2.3 | | | | | | | | | | | | | |
| 6.1.2.4 | | | | | | | | | | | | | |
| 6.1.2.5 | Source | 30 MR/hr | | MR/hr | | 250 MR/hr | | MR/hr | | 1300 MR/hr | | MR/hr | |
| 6.1.1.3 | Background | -1 MR/hr | | - MR/hr | | - MR/hr | | - MR/hr | | - MR/hr | | - MR/hr | |
| 6.1.3.1 | Actual Source Readings | 29 MR/hr | | MR/hr | | 249 MR/hr | | MR/hr | | 1289 MR/hr | | MR/hr | |
| 6.1.4.1 | Original Reading | 54 | | MR/hr | | 400 | | MR/hr | | 2000 | | MR/hr | |
| 6.1.4.2 | Original Reading Date | 1975 | | | | | | | | | | | |
| 6.1.4.3 | Expected Reading | 48 | | MR/hr | | 352 | | MR/hr | | 1762 | | MR/hr | |
| 6.1.4.4 | +15% of Expected Reading | 55 | | MR/hr | | 409 | | MR/hr | | 2026 | | MR/hr | |
| 6.1.4.5 | -15% of Expected Reading | 41 | | MR/hr | | 299 | | MR/hr | | 1498 | | MR/hr | |
| 6.1.5.1 | Actual Source Reading within 15% of Expected? Yes/No | * NO | | * | | * NO | | * | | * NO | | * | |

| | Setpoint Data | ALERT | INT | HIGH | INT |
|---|---|---|---|---|---|
| 6.1.6.1 | Required Setpoint | | | | |
| AL 6.1.6.3 / Hi 6.1.6.4 | Indicated "As Found" Setpoint | MR/hr | | MR/hr | |
| AL 6.1.6.7 / Hi 6.1.6.8 | "Tripped" Observed Setpoint | MR/hr | | MR/hr | |
| 6.1.6.9 | Observed Setpoint within One Minor Division of Required Yes/No | * | | * | |

| | Check Source, Recorder, Acceptance Criteria, Sign-Off | | |
|---|---|---|---|
| 6.1.7 | Observed Increase in Reading Due to Check Source | 0 MR/hr | INT |
| 6.1.7.2 | Recorder Trace Marked Yes/No | * | INIT. |

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".
** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY:
AND DATE: ____________________

APPROVED BY:
AND DATE ____________________

Place Old Cal.
Sticker Here

2612-R5
Revision 0
07/19/78

DATA SHEET I
RADIATION MONITORING SYSTEM

Procedure Step

6.1.1.2 MONITOR HP-R- 211 LOCAL METER AS FOUND AS LEFT RECORDER TRACE MARKED YES/NO INT

| | | FCK SOURCE KNOB POSITION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLOSED | | | | INTERMEDIATE | | | | OPEN | | | |
| | DESCRIPTION | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT |
| 6.1.2.3 | | | | | | | | | | | | | |
| 6.1.2.4 | | | | | | | | | | | | | |
| 6.1.2.5 | Source | 48 MR/hr | | MR/hr | | 350 MR/hr | | MR/hr | | 1800 MR/hr | | MR/hr | |
| 6.1.1.3 | Background | 1- MR/hr | | - MR/hr | | 1- MR/hr | | - MR/hr | | 1- MR/hr | | - MR/hr | |
| 6.1.3.1 | Actual Source Readings | 47 MR/hr | | MR/hr | | 349 MR/hr | | MR/hr | | 1799 MR/hr | | MR/hr | |
| 6.1.4.1 | Original Reading | 54 | | MR/hr | | 400 | | MR/hr | | 2000 | | MR/hr | |
| 6.1.4.2 | Original Reading Date | 1975 | | | | | | | | | | | |
| 6.1.4.3 | Expected Reading | 48 | | MR/hr | | 352 | | MR/hr | | 1762 | | MR/hr | |
| 6.1.4.4 | +15% of Expected Reading | 55 | | MR/hr | | 409 | | MR/hr | | 2026 | | MR/hr | |
| 6.1.4.5 | -15% of Expected Reading | 41 | | MR/hr | | 299 | | MR/hr | | 1498 | | MR/hr | |
| 6.1.5.1 | Actual Source Reading within 15% of Expected? Yes/No | * YES | | * | | * YES | | * | | * YES | | * | |

| | Setpoint Data | ALERT | INT | HIGH | INT |
|---|---|---|---|---|---|
| 6.1.6.1 | Required Setpoint | | | | |
| AL 6.1.6.3 Hi 6.1.6.4 | Indicated "As Found" Setpoint | MR/hr | | MR/hr | |
| AL 6.1.6.7 Hi 6.1.6.8 | "Tripped" Observed Setpoint | MR/hr | | MR/hr | |
| 6.1.6.9 | Observed Setpoint within One Minor Division of Required Yes/No | * | | * | |

Check Source, Recorder, Acceptance Criteria, Sign-Off

6.1.7 Observed Increase in Reading Due to Check Source 7 MR/hr INT

6.1.7.2 Recorder Trace Marked Yes/No * INIT.

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".

** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY:
AND DATE: ____________________

APPROVED BY:
AND DATE ____________________

Place Old Cal.
Sticker Here

Page A-65

2612-R5
Revision 0
07/19/78

DATA SHEET 1
RADIATION MONITORING SYSTEM

| Procedure Step | | | | | |
|---|---|---|---|---|---|
| 6.1.1.2 | MONITOR | HP-R-211 remote meter | AS FOUND | AS LEFT | RECORDER TRACE MARKED YES/NO INT |

| | | FCK SOURCE KNOB POSITION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLOSED | | | | INTERMEDIATE | | | | OPEN | | | |
| | DESCRIPTION | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT |
| 6.1.2.3 | | | | | | | | | | | | | |
| 6.1.2.4 | | | | | | | | | | | | | |
| 6.1.2.5 | ~~Source~~ Reading | .25 MR/hr | | MR/hr | | 200 MR/hr | | MR/hr | | 780 MR/hr | | MR/hr | |
| 6.1.1.3 | Background | 1 - MR/hr | | - MR/hr | | -1 MR/hr | | - MR/hr | | -1 MR/hr | | - MR/hr | |
| 6.1.3.1 | Actual Source Readings | 24 MR/hr | | MR/hr | | 199 MR/hr | | MR/hr | | 779 MR/hr | | MR/hr | |
| 6.1.4.1 | Original Reading (1975) | 54 | | MR/hr | | 400 | | MR/hr | | 2000 | | MR/hr | |
| 6.1.4.2 | Original Reading Date | 1975 | | | | | | | | | | | |
| 6.1.4.3 | Expected Reading | 48 | | MR/hr | | 352 | | MR/hr | | 1762 | | MR/hr | |
| 6.1.4.4 | +15% of Expected Reading | 55 | | MR/hr | | 405 | | MR/hr | | 2026 | | MR/hr | |
| 6.1.4.5 | -15% of Expected Reading | 41 | | MR/hr | | 299 | | MR/hr | | 1498 | | MR/hr | |
| 6.1.5.1 | Actual Source Reading within 15% of Expected? Yes/No | * NO | | * | | * NO | | * | | * NO | | * | |

| | Setpoint Data | ALERT | INT | HIGH | INT |
|---|---|---|---|---|---|
| 6.1.6.1 | Required Setpoint | | | | |
| AL 6.1.6.3 / Hi 6.1.6.4 | Indicated "As Found" Setpoint | MR/hr | | MR/hr | |
| AL 6.1.6.7 / Hi 6.1.6.8 | "Tripped" Observed Setpoint | MR/hr | | MR/hr | |
| 6.1.6.9 | Observed Setpoint within One Minor Division of Required Yes/No | * | | * | |

Check Source, Recorder, Acceptance Criteria, Sign-Off

6.1.7 Observed Increase in Reading Due to Check Source 4 MR/hr INT

6.1.7.2 Recorder Trace Marked Yes/No * INIT.

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".
** Record "Pegged" if Meter Pegs High Due to Background.
New Calibration Sticker Attached Yes/No

PERFORMED BY: AND DATE: E. Heffner 8-15-80

APPROVED BY: AND DATE

Place Old Cal. Sticker Here

DATA SHEET
RADIATION MONITORING SYSTEM

Procedure Step

6.1.1.2 MONITOR HP-R-211 remote meter AS FOUND AS LEFT RECORDER TRACE MARKED YES/NO INT

| | | FCK SOURCE KNOB POSITION | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLOSED | | | | INTERMEDIATE | | | | OPEN | | | |
| | DESCRIPTION | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT | RATEMETER | INT | RECORDER | INT |
| 6.1.2.3 | | | | | | | | | | | | | |
| 6.1.2.4 | | | | | | | | | | | | | |
| 6.1.2.5 | ~~Source~~ READING | 45 MR/hr | | MR/hr | | 350 MR/hr | | MR/hr | | 1750 MR/hr | | MR/hr | |
| 6.1.1.3 | Background | 1- MR/hr | | - MR/hr | | 1- MR/hr | | - MR/hr | | 1- MR/hr | | - MR/hr | |
| 6.1.3.1 | Actual Source Readings | 44 MR/hr | | MR/hr | | 349 MR/hr | | MR/hr | | 1749 MR/hr | | MR/hr | |
| 6.1.4.1 | Original Reading (1975) | 54 | | MR/hr | | 400 | | MR/hr | | 2000 | | MR/hr | |
| 6.1.4.2 | Original Reading Date | 1975 | | | | | | | | | | | |
| 6.1.4.3 | Expected Reading | 48 | | MR/hr | | 352 | | MR/hr | | 1762 | | MR/hr | |
| 6.1.4.4 | +15% of Expected Reading | 55 | | MR/hr | | 405 | | MR/hr | | 2026 | | MR/hr | |
| 6.1.4.5 | -15% of Expected Reading | 41 | | MR/hr | | 299 | | MR/hr | | 1498 | | MR/hr | |
| 6.1.5.1 | Actual Source Reading within 15% of Expected? Yes/No | * YES | | * | | * YES | | * | | * YES | | * | |

Setpoint Data

| | | ALERT | INT | HIGH | INT |
|---|---|---|---|---|---|
| 6.1.6.1 | Required Setpoint | | | | |
| AL 6.1.6.3<br>Hi 6.1.6.4 | Indicated "As Found" Setpoint | MR/hr | | MR/hr | |
| AL 6.1.6.7<br>Hi 6.1.6.8 | "Tripped" Observed Setpoint | MR/hr | | MR/hr | |
| 6.1.6.9 | Observed Setpoint within One Minor Division of Required Yes/No | * | | * | |

Check Source, Recorder, Acceptance Criteria, Sign-Off

6.1.7 Observed Increase in Reading Due to Check Source 7 MR/hr INT

6.1.7.2 Recorder Trace Marked Yes/No * INIT.

* Acceptance Criteria: All Yes/No Blanks Indicate "Yes".

** Record "Pegged" if Meter Pegs High Due to Background.

New Calibration Sticker Attached Yes/No

PERFORMED BY: AND DATE: E. Heffner 8-15-80

APPROVED BY: AND DATE

Place Old Cal. Sticker Here

# SECTION A.5

## PHOTOGRAPHS, STRIP CHARTS, AND RECORDER LOG PAGES FROM PRE-REMOVAL AND POST-REMOVAL MEASUREMENTS

# SECTION A.5.1

# RECORDER LOG PAGES

# FIELD SERVICE DATA SHEET

PL Name T. Smith

Page No. 1

DATA SHEET - PLANT: TMI

UNIT 2    RUN TP101    DATE 8-13-80

| TIME | | TAPE ft | PWR | |
|---|---|---|---|---|
| | | | | TAPE Te-1138 |
| START | 10:20 A.m. | 100 ft | | SPEED 7 1/2 ips |
| STOP | 11:35 | end of tape | | BAND |

ROD POSITION: GROUP ___, ___; GROUP ___, ___; GROUP ___, ___.

BORON (ppm) ___ EFPD ___ CYCLE ___

| RECORDER CHANNEL | SIGNAL | AMP | BW | GAIN | VDC |
|---|---|---|---|---|---|
| 1 | Hp-PT-0211 | | | 1 | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |

**COMMENTS:** AT Footage of 220 ATTENUATION of ~~20~~ 2 WAS used

TEC Form No.

8-13-80

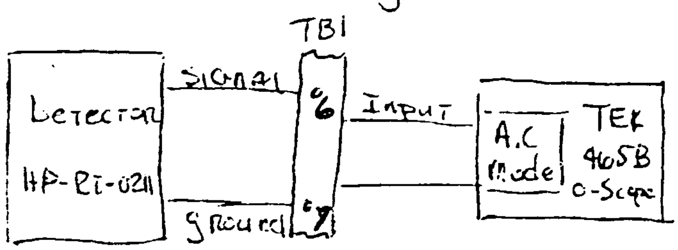
MEASUREMENTS AT TMI CONTROL ROOM

EG&G Idaho Support

TAPE RECORDING LOG SHEET

- Channel 1 of Store Four Recorder; set on Direct Record
- Tape # 1138
- Tape Speed 7 1/2 ips
- The Following Test Footage was Recorded
  - 0-25 ft → 1 volt peak to peak at 10 hz
  - 25-50 ft → 1 volt " at 100 hz
  - 50-75 ft → 1 volt " " at 1k hz
- 100 ft The Start of The Actual Test

The following Diagram is the Recorded Set up




(old) S/N ____

Tek Scope was calibrated with the following instrument

Tec# 7801; Function Generator

Tec# 8030; Freq. Counter

Tec# 8032; DMM

Check Source Switch activated at Tape footage of 876

Check Source deactivated at 900 ft.

PL Name T. Smith

Page No. 2

DATA SHEET - PLANT: TMI

UNIT 2 RUN TP102 DATE 8-19-80

| TIME | TAPE ft | PWR | |
|---|---|---|---|
| START ____ | 100 | ____ | TAPE TE-1139 |
| STOP ____ | end of Tape | ____ | SPEED 7½ ips |
| | | | BAND ____ |

ROD POSITION: GROUP ____, ____; GROUP ____, ____; GROUP ____, ____.

BOROM (ppm) ____ EFPD ____ CYCLE ____

| RECORDER CHANNEL | SIGNAL | AMP | BW | GAIN | VDC |
|---|---|---|---|---|---|
| 1 | HD-PT-0211 | | | 1 | |
| 2 | SIN-111 | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |

COMMENTS:

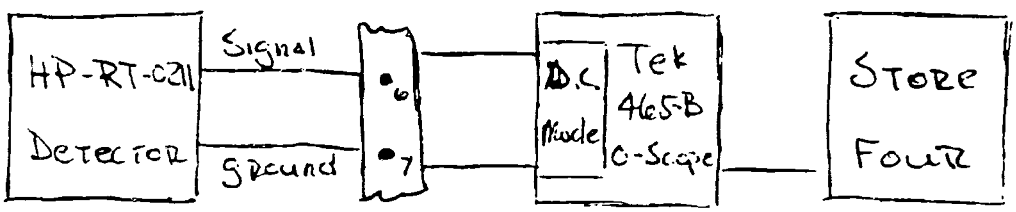
EC Form No.

8-14-80

MEASUREMENTS AT TMI Control Room
EG&G Idaho Support

TAPE Recording Log Sheet
TApe # 1139
TApe Speed 7½ ips
ATTENUATION 1
Channel 1 Signal from HP-RT-0211

Test Set up




New S/N 111

Tek Scope was calibrated 8-14-80 with the following instruments at 10:1 attenuation
Tec # 7801 - Function Generator
Tec # 8030 - Frequency Counter
Tec # 8032 - DMM

Calibration Footage
25-75 ft. → 2.8V peak to peak @ 500hz.

Tape # 1139 con't.

Starting footage; 125 → Starting Time 2:40.
15 minutes into Recording At 725 ft.
Alternate measurements were started

1) Check Source Switch Activated At Tape footage of 876
2) Check Source Switch deactivated At Tape footage of 960
3) Check Source Switch Activated At Tape footage 1111
4) Check Source Switch deactivated At Tape footage 1165

These steps were in the process of doing steps 18 while step 17 was in progress

Recorder disconnected At 1818 ft, reconnected At 1830 ft

Tape Stopped At 2312 ft.

PL Name T. Smith Page No. 3

DATA SHEET - PLANT: 8-15-80

UNIT 2 RUN TP103 DATE 8-15-80

| TIME | TAPE ft | PWR | |
|---|---|---|---|
| START | 100 | | TAPE Tec - 1117 |
| STOP | end of Tape | | SPEED 7 1/2 ips |
| | | | BAND |

ROD POSITION: GROUP ____, ____; GROUP ____, ____; GROUP ____, ____.

BORON (ppm) ____ EFPD ____ CYCLE ____

| RECORDER CHANNEL | SIGNAL | AMP | BW | GAIN | VDC |
|---|---|---|---|---|---|
| 1 | | | | 1 | |
| 2 | Hp-PT-0211 | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |

COMMENTS:

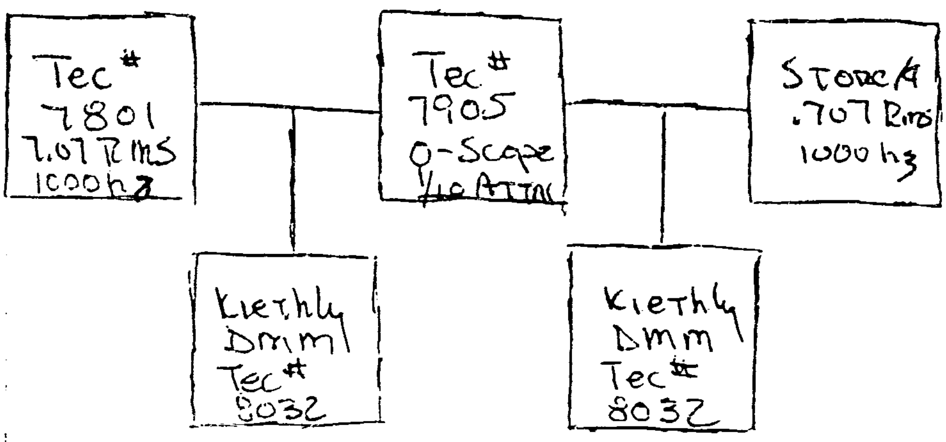
TEC Form No.

8-15-80

MEASUREMENT AT TMI CONTROL ROOM
EG+G Idaho Support

Tape Recording Log Sheet
Tape # 1147
Tape Speed 7½ i.p.s.

Calibration Setup




Calibration Footage

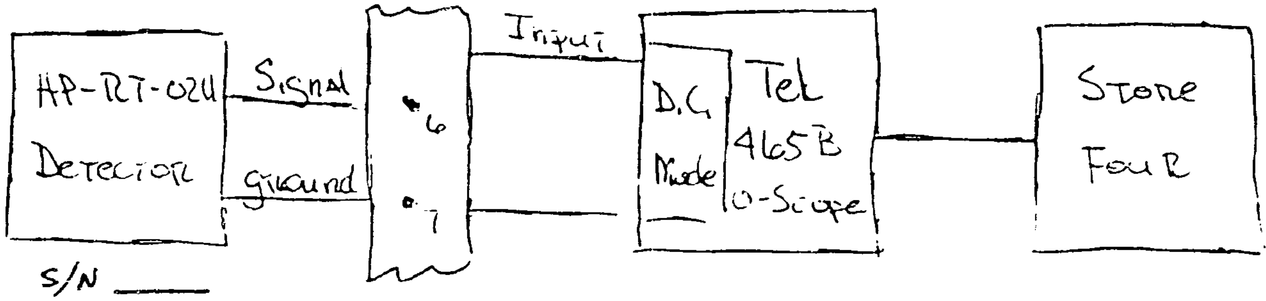
0-45 ft. - .707 RMS 1000hz, 7½ i.p.s. this is garbage as signal was switched from Channel #1 to Channel #2 1/10 ATTENUATION

60-83 ft - .707 Rms 1khz on Channel #2 7½ i.ps. 1/10 ATTENUATION

100 ft to end of tape ; Channel #2 recording of HP-RT-0211 output, 7½ ips 1/1 ATT.

* 2230 ft. power to the dectector was disconnected

Recording Set-up




(old) S/N ____

# SECTION A.5.2

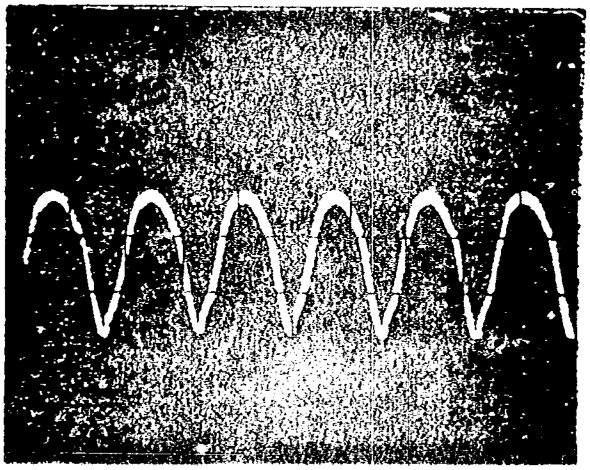
## PRE-REMOVAL PHOTOGRAPHS OF TIME AND FREQUENCY DOMAIN MEASUREMENTS OF WAVEFORMS

PRE-REMOVAL

Time Domain

| | | |
|---|---|---|
| #5.a | Check Source to GND<br>Photo #3, 4, 5 | |
| #5.b | Check Source to GND<br>Photo #6, 7, 8 | |
| #5.c | +6.00 VDC to GND<br>Photo #9, 10, 11 | |
| #5.d | Detector Signal to GND<br>Photo #12, 13, 14 | |
| #5.e | +10 VDC to GND<br>Photo #15, 16, 17 | |
| #5.f | GND to AC GND<br>Photo #18, 19, 20 | 110 VAC<br>fuse blown |
| #5.g | GND to AC GND<br>Photo #21, 22, 23 | Replaced<br>blown fuse |

PHOTO #3

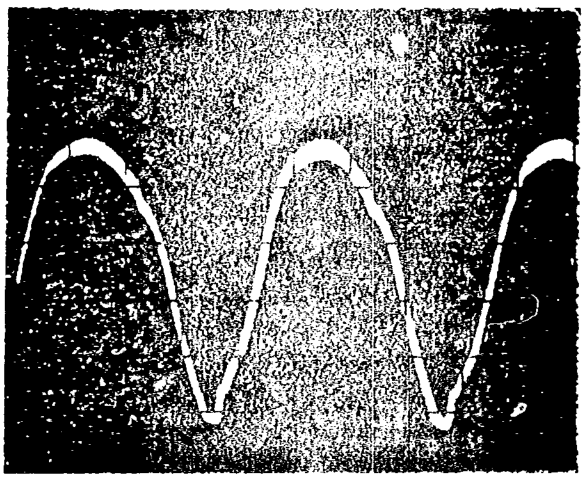


TB 109-1
TB 109-10 ] Check Source

Vert. Gain: 2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #4

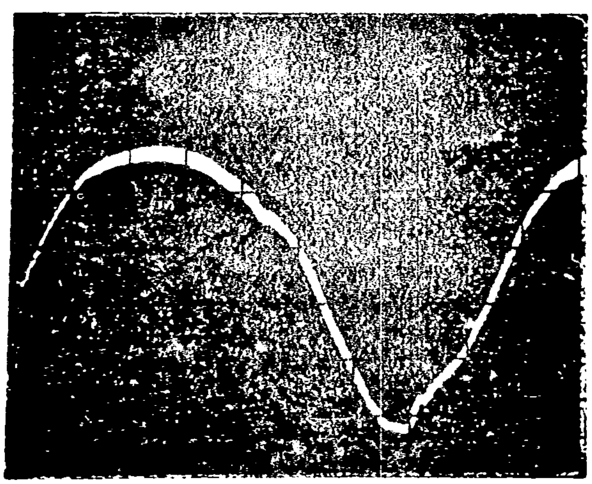


TB 109-1
TB 109-10 ] Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

PHOTO #5

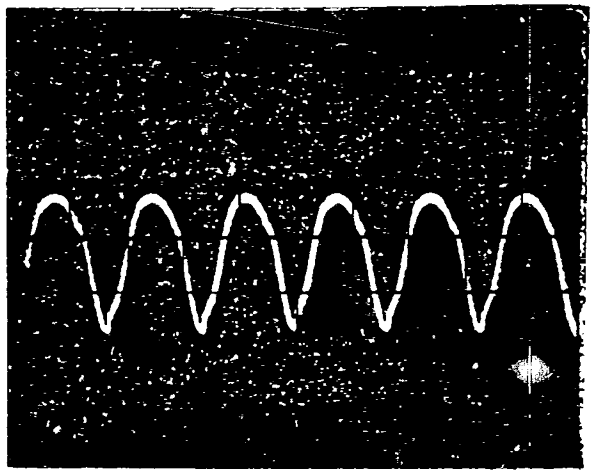


TB 109-1
TB 109-10 ] Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 1ms/Div

PHOTO #6

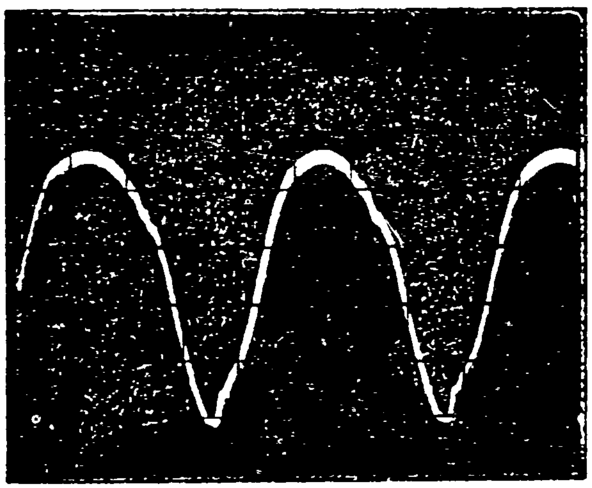


TB 109-2
TB 109-10 Check Source

Vert. Gain: 2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #7

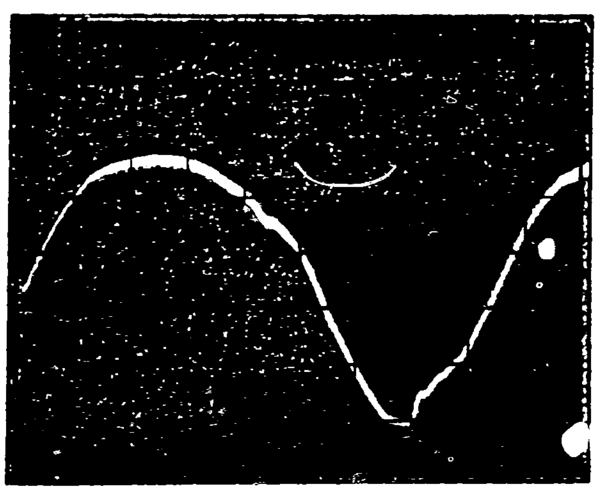


TB 109-2
TB 109-10 Check Source

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

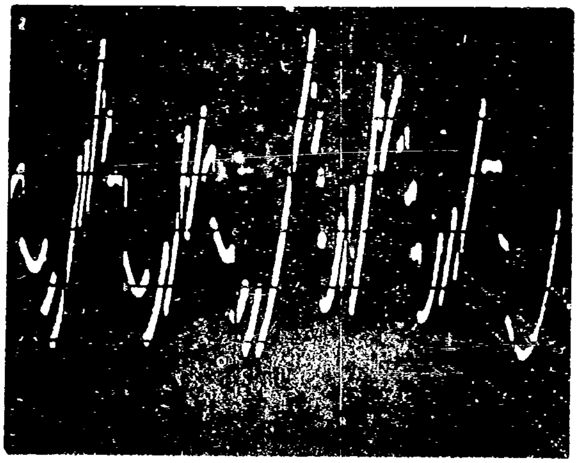
PHOTO #8



TB 109-2
TB 109-10 Check Source

Vert. Gain: 1V/Div
Horiz. Time Base: 1ms/Div

PHOTO #9

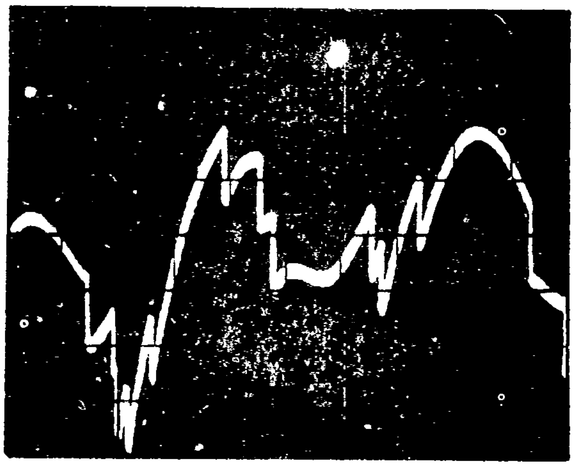


TB 109-5 ⎤
⎥ +600V
TB 109-10 ⎦

Vert. Gain: 0.2V/Div

Horiz. Time Base: 5ms/Div

PHOTO #10

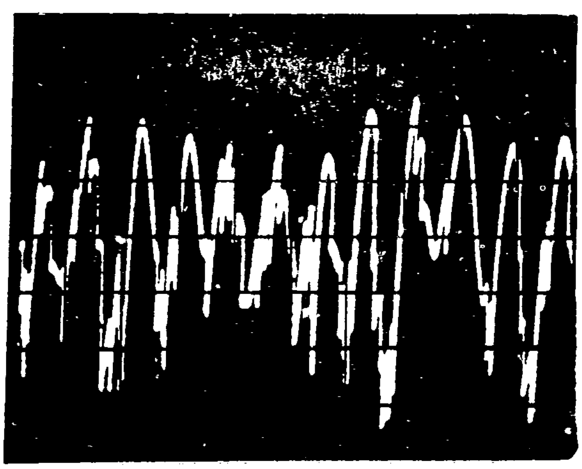


TB 109-5 ⎤
⎥ +600V
TB 109-10 ⎦

Vert. Gain: 0.2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #11

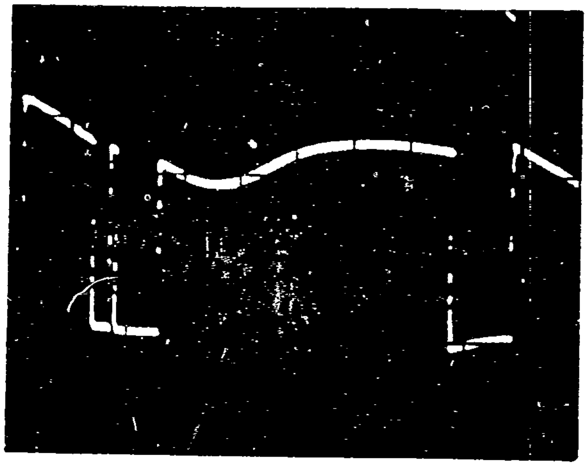


TB 109-5 ⎤
⎥ +600V
TB 109-10 ⎦

Vert. Gain: 0.2V/Div

Horiz. Time Base: 10ms/Div

PHOTO #12

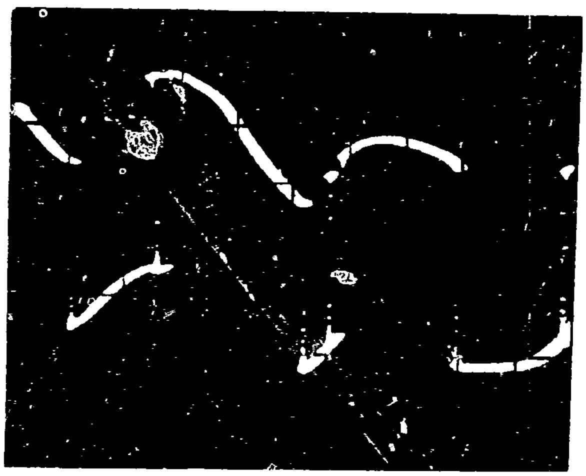


TB 109-6 ⎤
TB 109-7 ⎦ Signal

Vert. Gain: 1V/Div

Horiz. Time Base: 1ms/Div

PHOTO #13

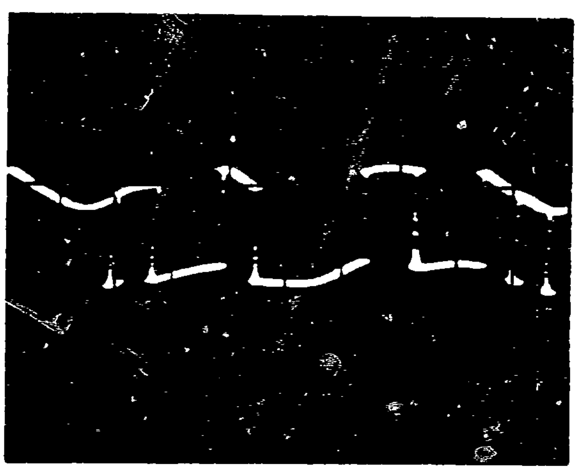


TB 109-6 ⎤
TB 109-7 ⎦ Signal

Vert. Gain: 1V/Div

Horiz. Time Base: 2ms/Div

PHOTO #14

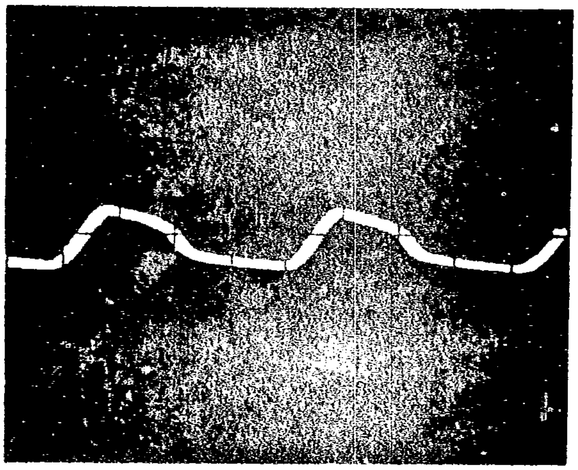


TB 109-6 ⎤
TB 109-7 ⎦ Signal

Vert. Gain: 2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #15

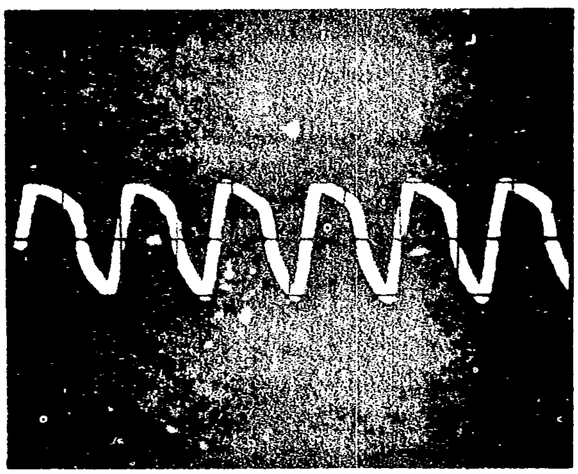


TB 109-8 ]
TB 109-10 ] +10V

Vert. Gain: 2V/Div

Horiz. Time Base: 2ms/Div

PHOTO #16

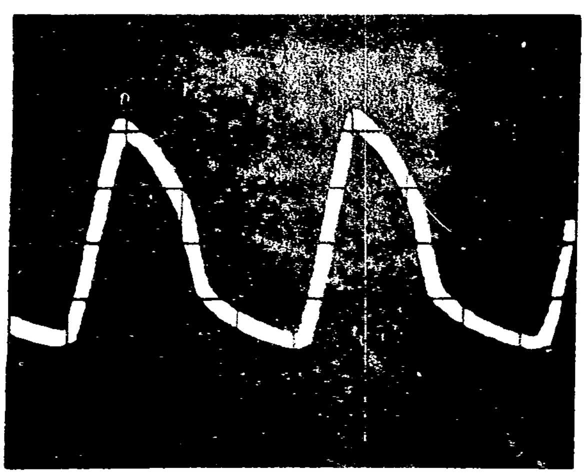


TB 109-8 ]
TB 109-10 ] +10V

Vert. Gain: 1V/Div

Horiz. Time Base: 5ms/Div

PHOTO #17

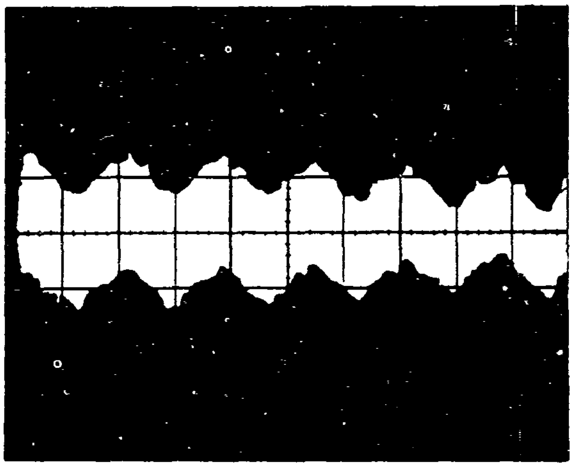


TB 109-8 ]
TB 109-10 ] +10V

Vert. Gain: 0.5V/Div

Horiz. Time Base: 2ms/Div

PHOTO #18

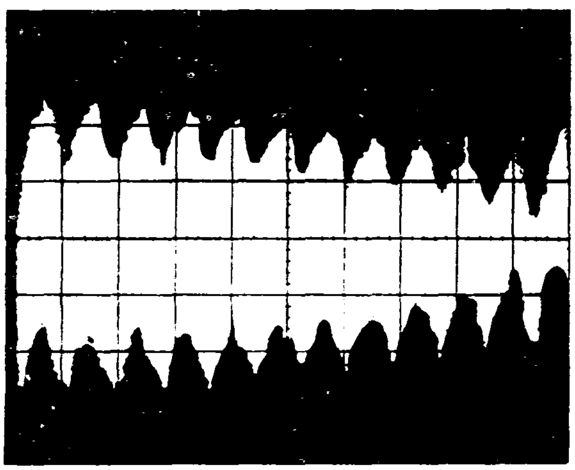


TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 2mV/Div

Horiz. Time Base: 10ms/Div

PHOTO #19

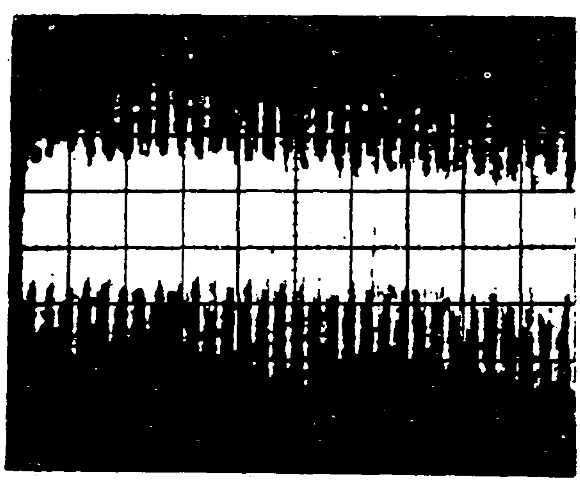


TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 1mV/Div

Horiz. Time Base: 20ms/Div

PHOTO #20



TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 1mV/Div

Horiz. Time Base: 0.2ms/Div

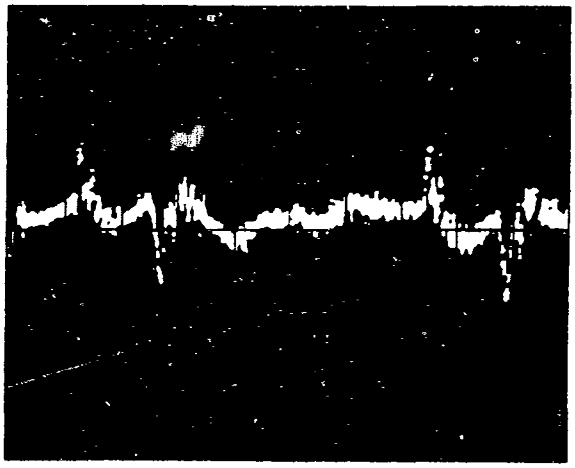


PHOTO #21

TB 109-10 ⎤
 ⎥GND
TB 501-27 ⎦

Vert. Gain: 10mV/Div

Horiz. Time Base: $10\mu s$/Div

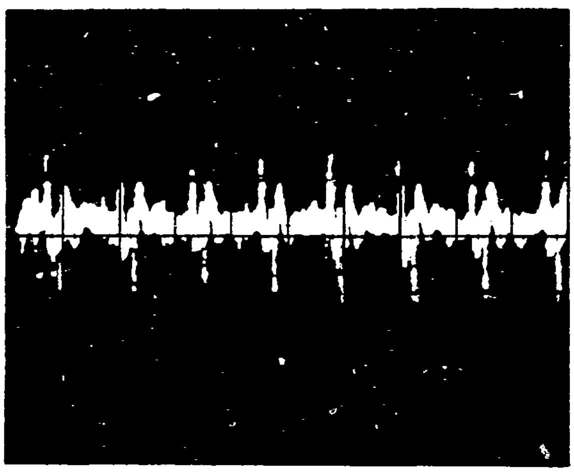


PHOTO #22

TB 109-10 ⎤
 ⎥GND
TB 501-27 ⎦

Vert. Gain: 10mV/Div

Horiz. Time Base: $50\mu s$/Div

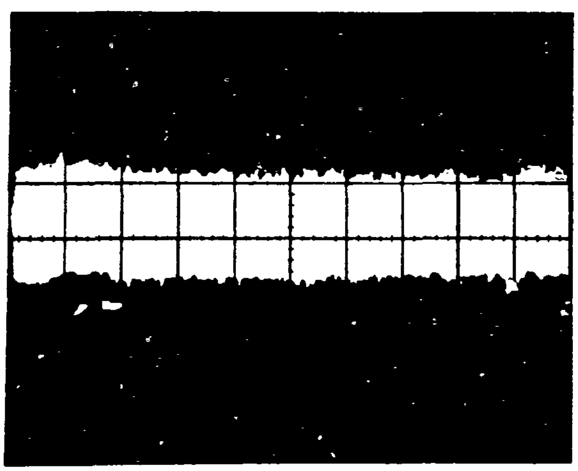


PHOTO #23

TB 109-10 ⎤
 ⎥GND
TB 501-27 ⎦

Vert. Gain: 5mV/Div

Horiz. Time Base: 2ms/Div

PHOTO #24

TB 109-8 ⎤
TB 109-10 ⎦ +10V

BW - 3 KHz

Horiz. Scale: 200 KHz/Div

Scan Time - 100 ms/Div

Vert. Scale: OdB Ref; 10dB/Div

Input Attenuation: 40 dB

PHOTO #25

TB 109-8 ⎤
TB 109-10 ⎦ +10V

BW - 3 KHz

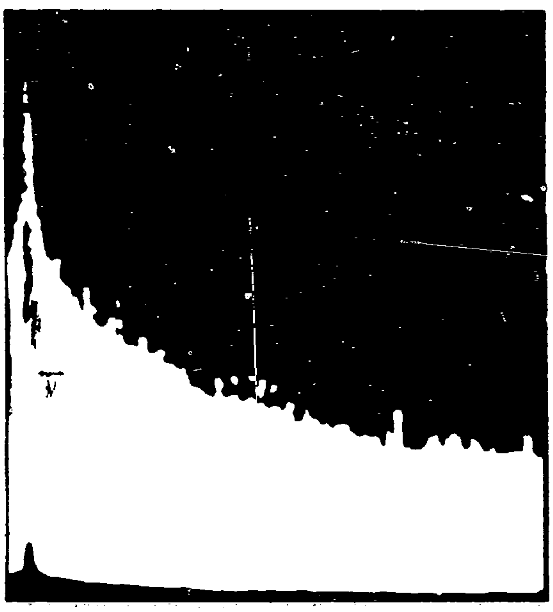
Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: OdB Ref; 10dB/Div

Input attenuation: 40 dB

PHOTO #26



TB 109-6 ] Signal
TB 109-7 ]

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

PHOTO # 27

TB 107-5
TB 107-10 +600V

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time: 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

0.109 RMS

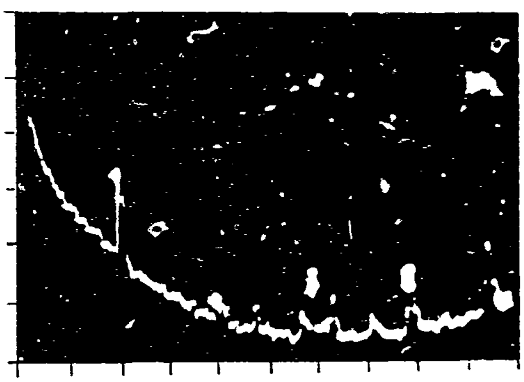


PHOTO #28

TB 109-5 ⎤
TB 109-10 ⎦ +600V

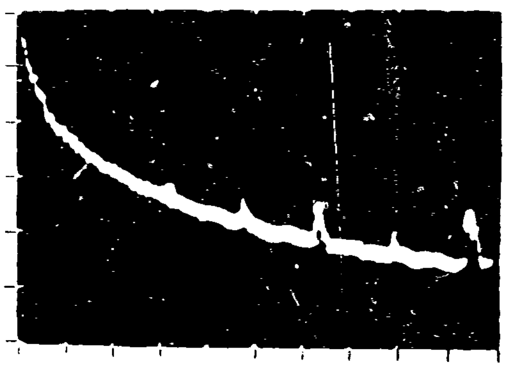
Range: 0 - 100 KHz

20 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

1.35 RMS

PHOTO # 29



TB 109-6 ] Signal
TB 109-7 ]

Range: 0 - 100 KHz

32 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

0.301 RMS

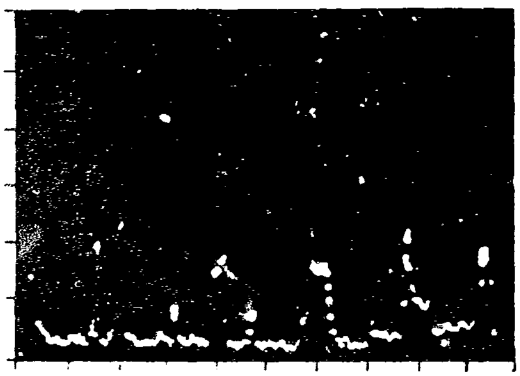


PHOTO #30

TB 109-8
TB 109-10 +10V

Range: 0 - 100 KHz

~16 KHz Harmonics intensified

~20 KHz Harmonics also present

Vert. Scale: +20 dB Ref; 10 dB/Div

0.712 RMS

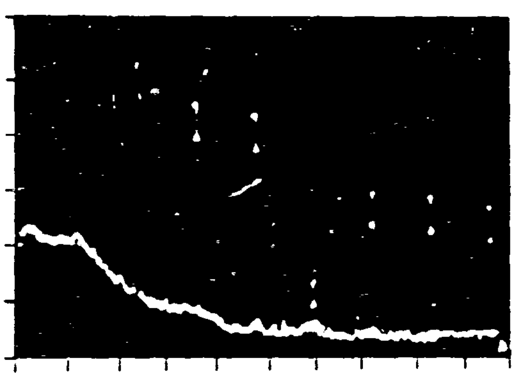


PHOTO #31

TB 109-8
TB 109-10 +10V

Range: 0 - 1 KHz

~120 KHz Harmonics Intensified

Vert. Scale: +20 dB Ref; 10 dB/Div

# SECTION A.5.3

## PRE-REMOVAL TDR MEASUREMENTS ON CABLE

(Detector Attached)

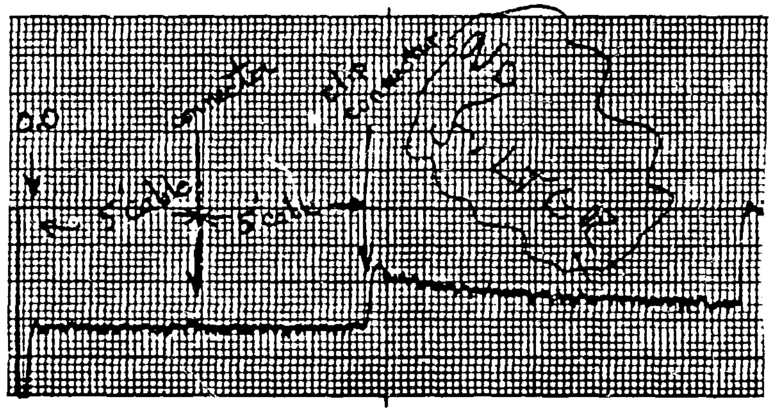
# PRE-REMOVAL TDR MEASUREMENTS

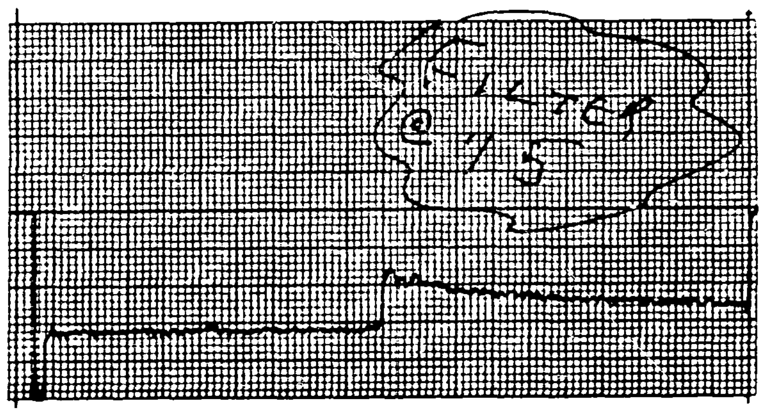
| Test | Verify Operability & Necessary LP Filter for Recording | |
|---|---|---|
| #12.a | Checksource | Tests 12a-1, 12a-2 |
| #12.b | RG59 | Tests 12b-1, 12b-2 |
| #12.c | RG58 | Tests 12c-1, 12-c2 |
| #12.d | +10V | Tests 12d-1, 12-d2 |
| #12.e | GND-GND | Tests 12e-1, 12-e2 |
| #12.f | RG58+ 5' cable and terminal block inserted | Tests 12f-1, 12f-2 |

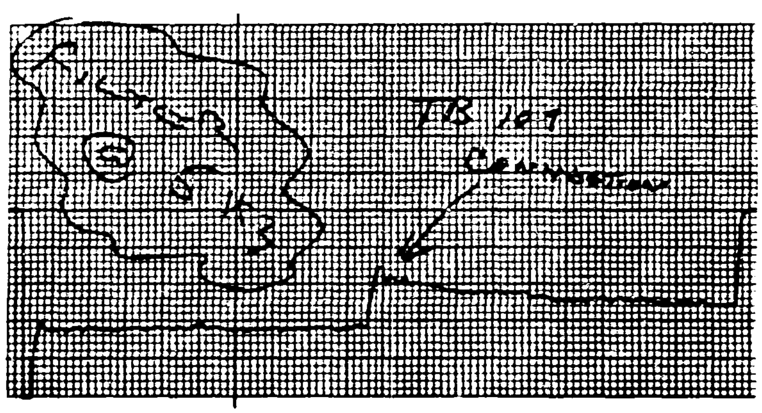
TDR Test Runs

To Determine LP Filters
Setting For Strip Chart Output
Test Run - 10' Coax With Clips

Horiz. Scale: Uncalibrated Chart Speed: 5 mm/s



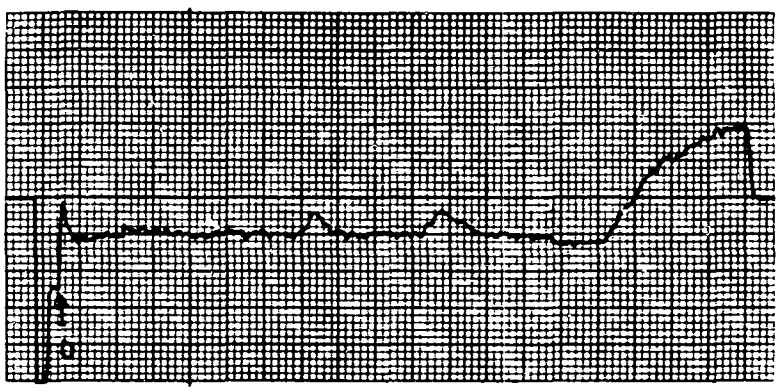



Test 12a - 1

From Blue to Orange

Checksource



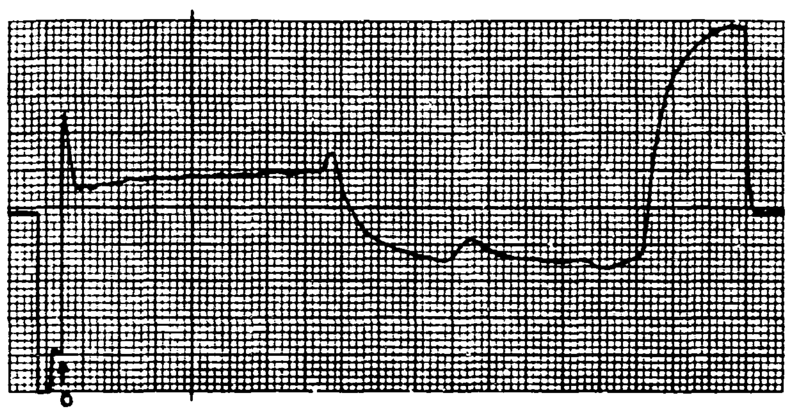
Horizontal Scale: 26.32 ft./Div

Vertical Scale: 0.25 V/Div; 500 m ρ/Div

Test 12b-1

From RG 59/U Center to RG 59/U Shield

600V to Shield



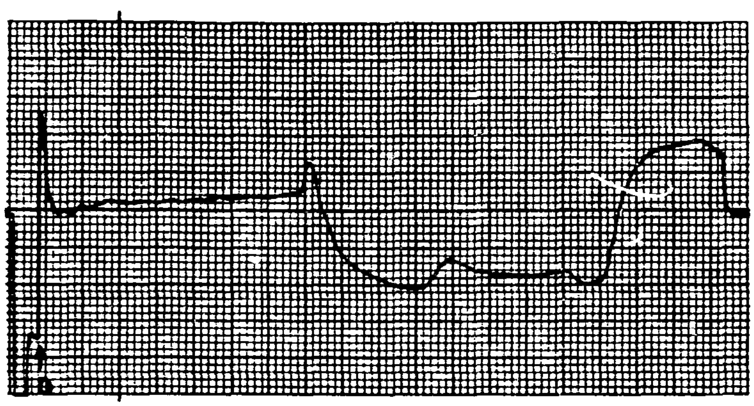
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12c-1

From RG 58/U Center to RG 58/U Shield

Signal to Shield



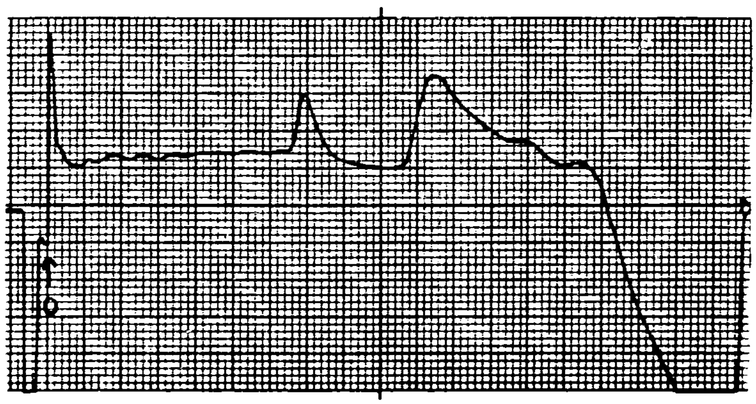
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12d - 1

From Red to Black

+10V to GND



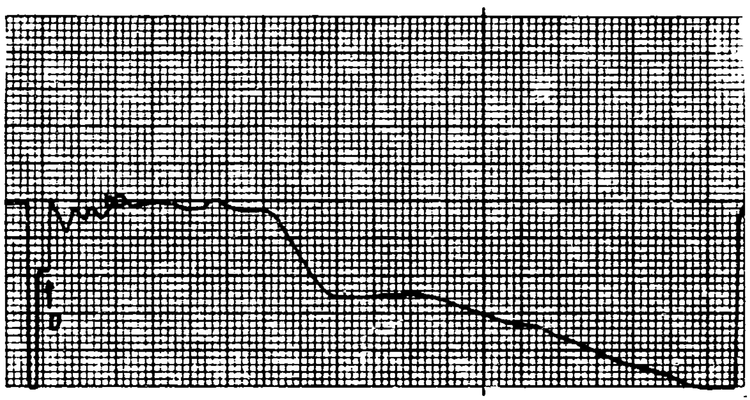
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 mρ/Div

Test 12e - 1

From Black to TB109-10

GND to GND



Horizontal Scale: 26.32 ft/Div

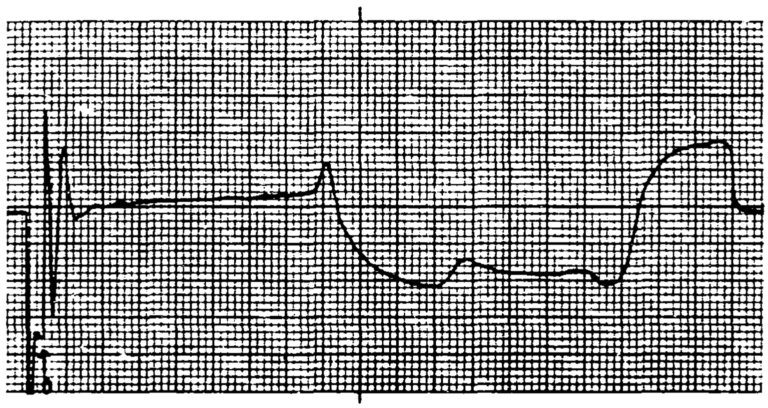
Vertical Scale: 0.25V/Div; 500 mρ/Div

Test 12f - 1

From RU 58/U Shield to RG 58/U Center

Shield to Signal

(12c-1 with new cable and terminal black
inserted @ ~ 10')

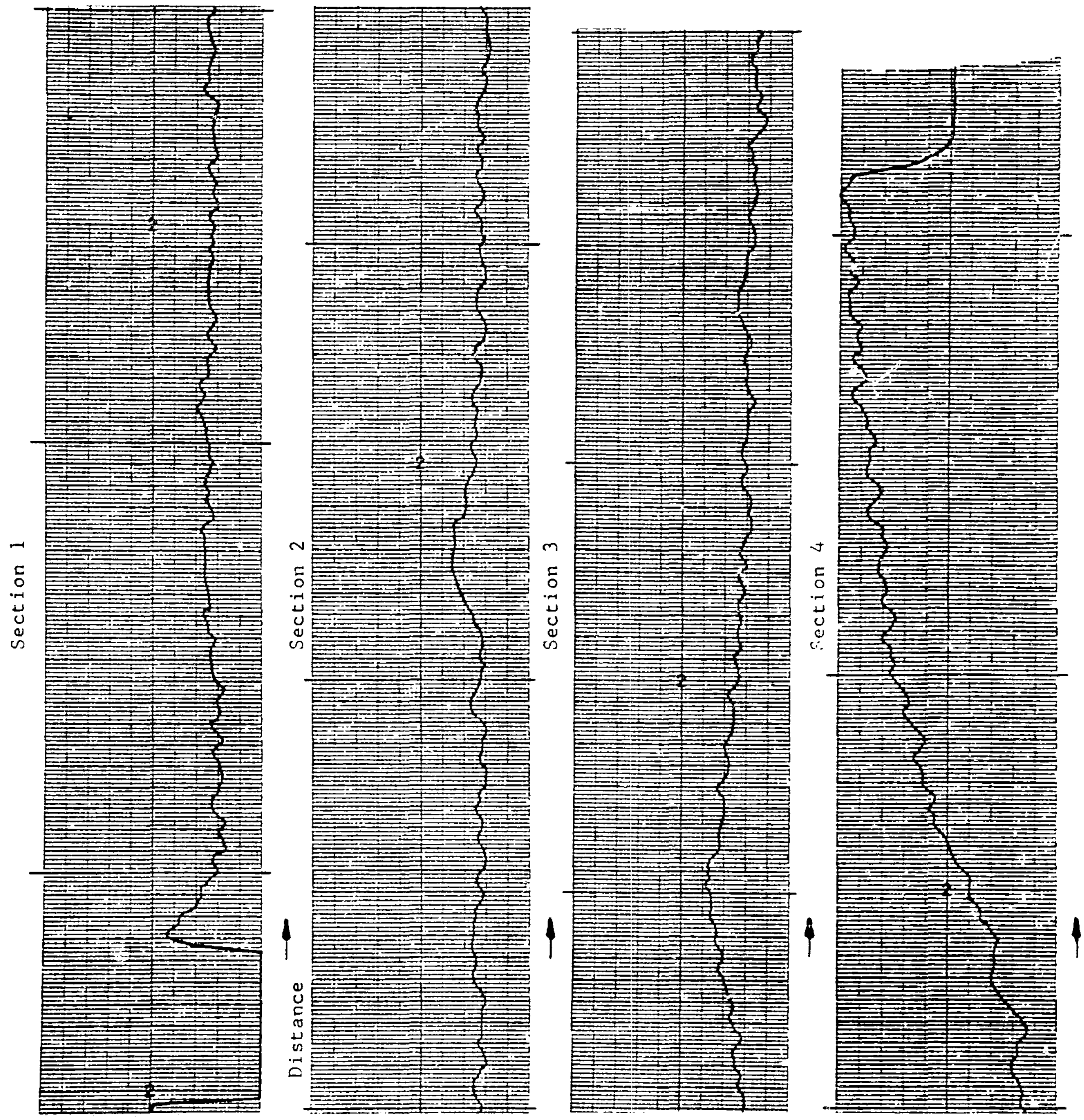


Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10V/Div; 500 m$\rho$/Div

Test 12a-2: From Blue to Orange - Checksource

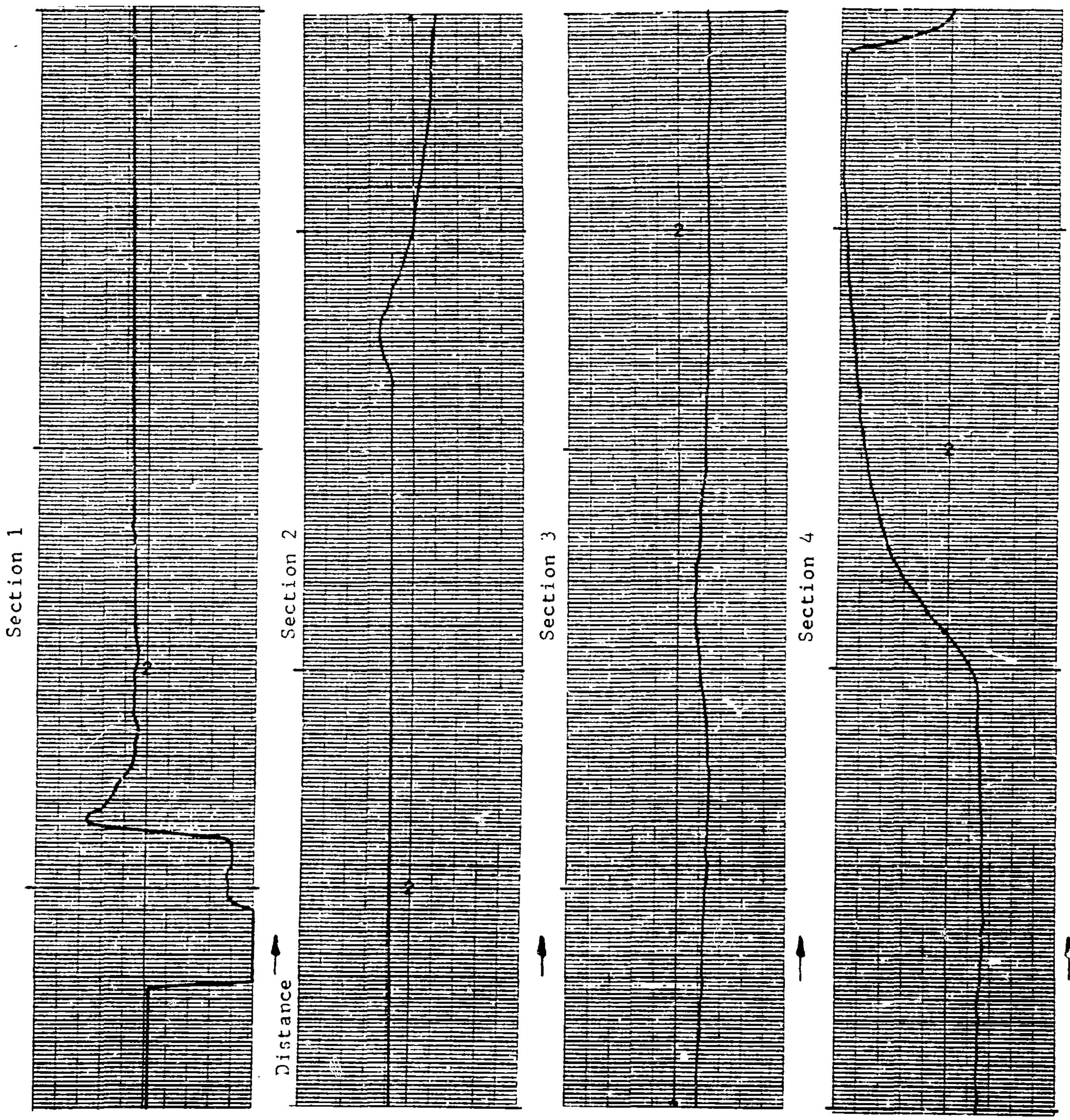
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 m$\rho$/Div



Test 12b-2: From RG 59/U Center to RG 59/U Shield

600 V to Shield

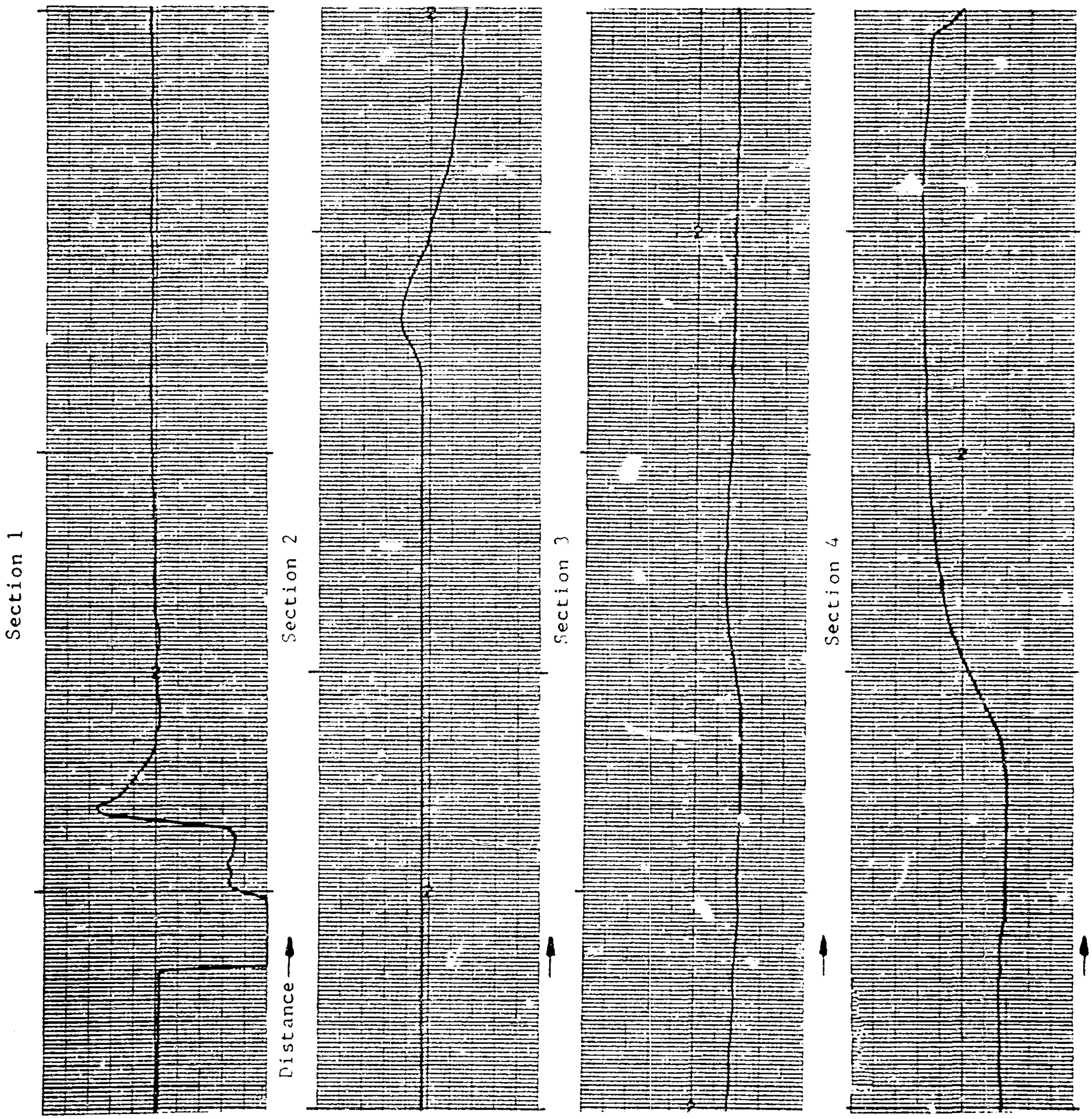
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mρ/Div



Test 12c-2: From RG 58/U Center to RG 58/U Shield

Signal to Shield

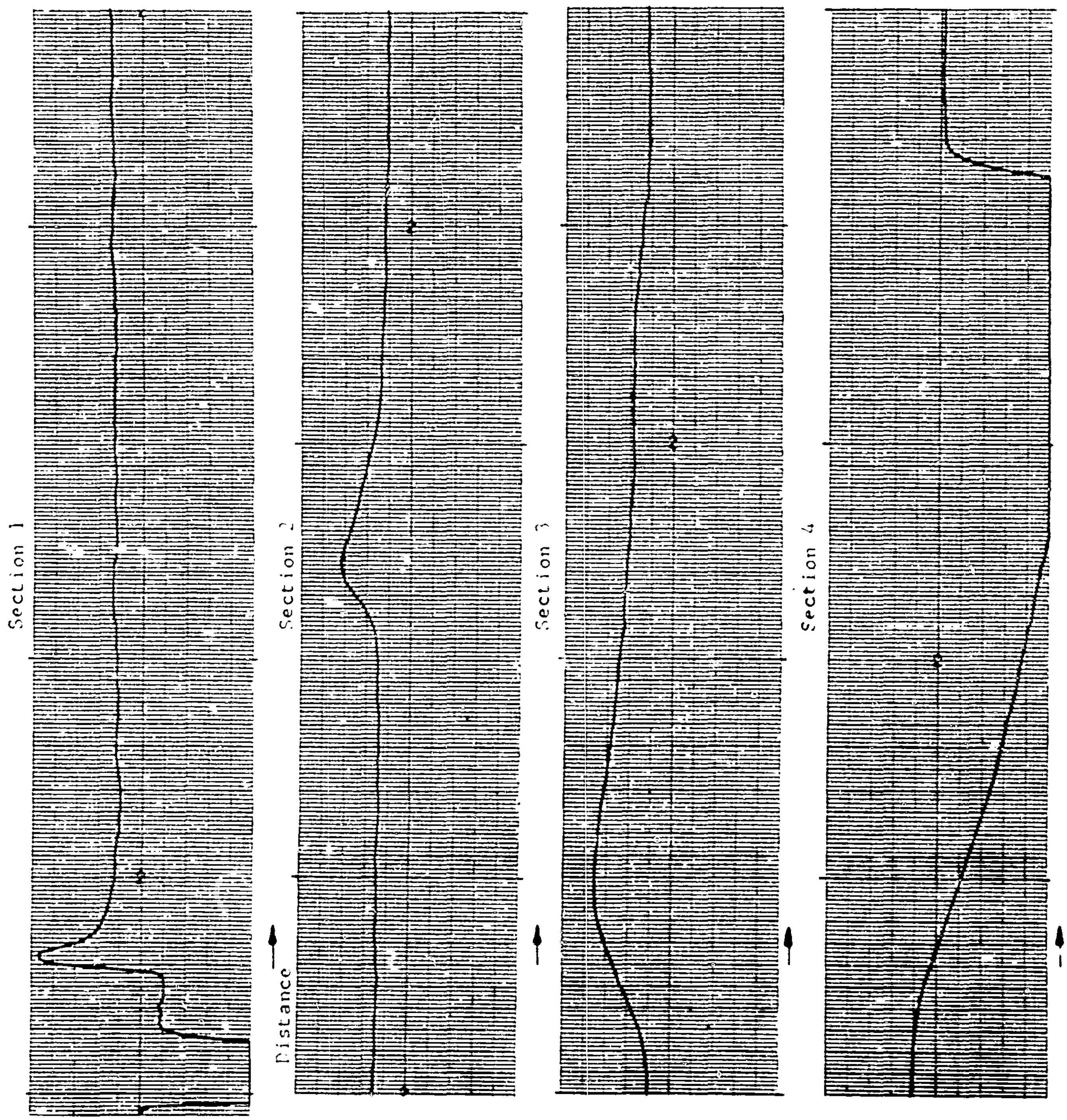
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mp/Div



Test 12c-2: From Red to Black

+10' to END

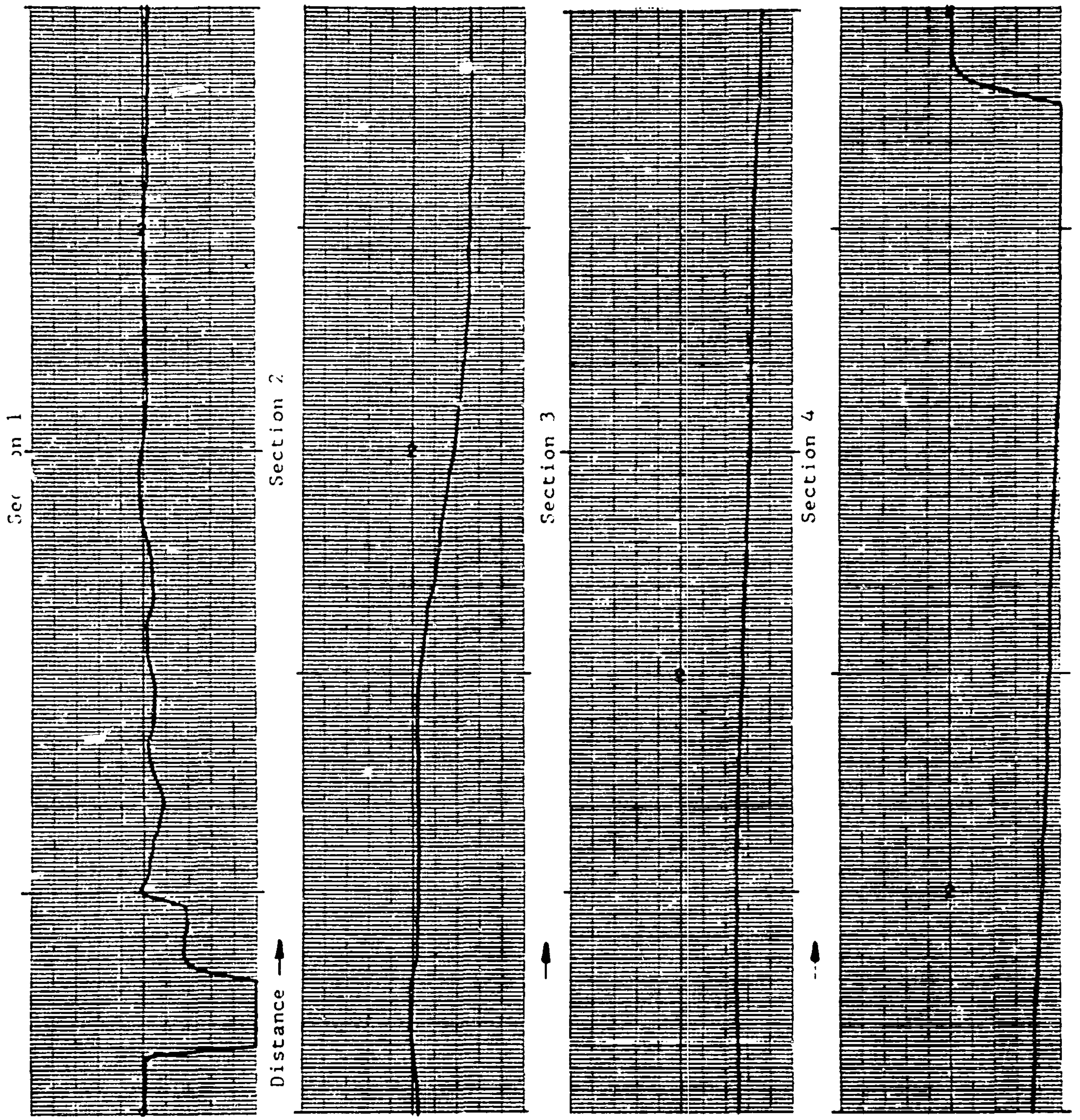
Horizontal Scale: 2.832 ft/Div Vertical Scale: 0.10V/Div, 500 mc/Div



Test 12e-2: From Black to TB109-10

GND to GND

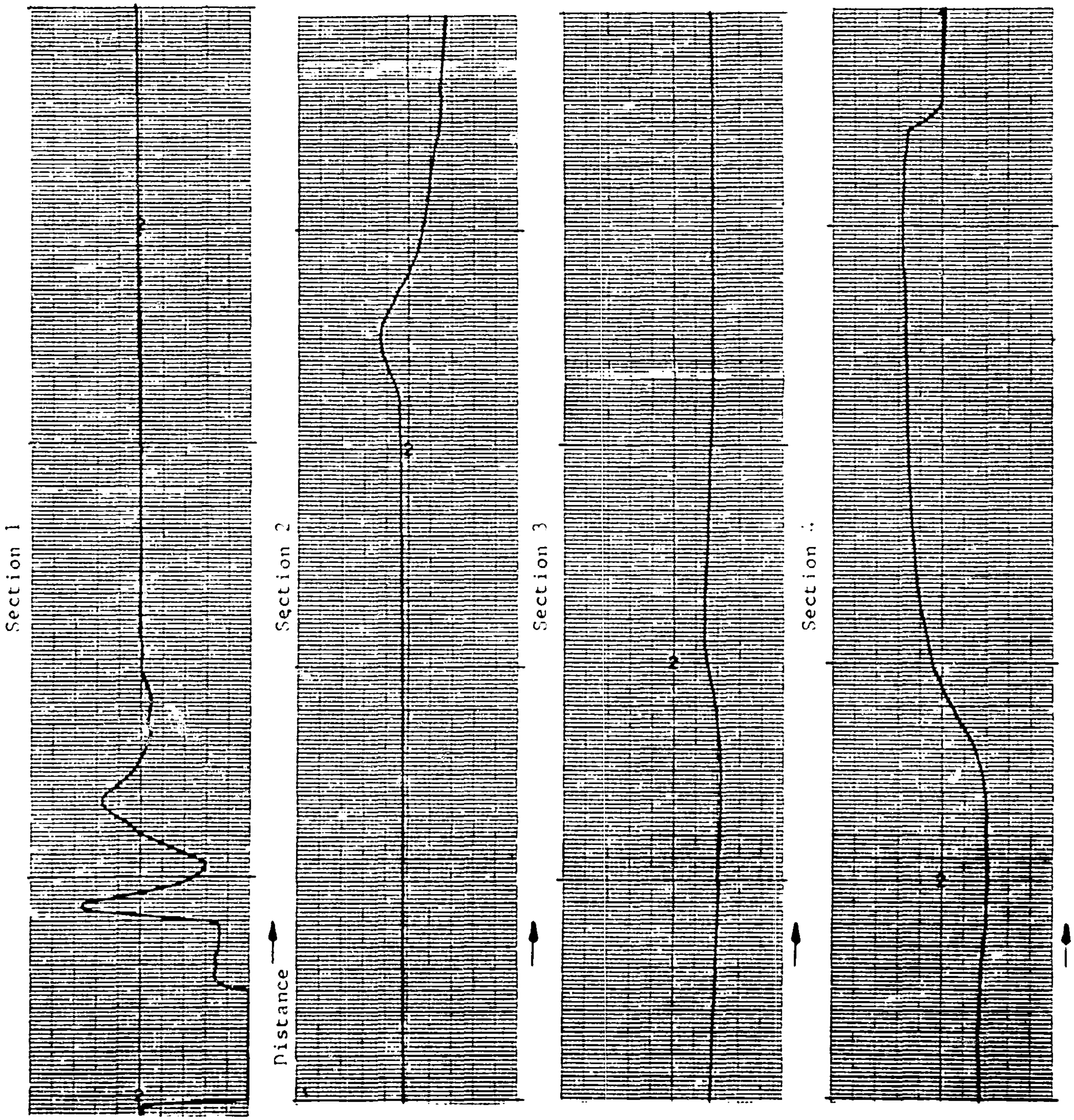
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mρ/Div



Test 12f-2: From RG 58/U Shield to RG 58/U Center

Shield to Signal (Extra test cable and terminal block)

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10V/Div; 500 mρ/Div



# SECTION A.5.4

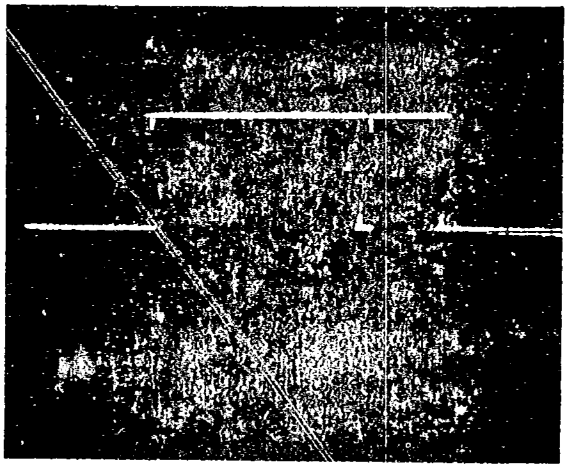
## TIME AND FREQUENCY DOMAIN MEASUREMENTS OF WAVEFORMS ON DETECTOR INSTALLED IN THE ANTEROOM

PRE-REMOVAL

Time Domain

| | |
|---|---|
| #19.a | Check Source to GND<br>Photo #35, 36, 37 |
| #19.b | Check Source to GND<br>Photo #38, 39, 40 |
| #19.c | +600 VDC to GND<br>Photo #41, 42, 43 |
| #19.d | Detector Signal to GND<br>Photo #32, 33, 34 |
| #19.e | +10VDC to GND<br>Photo #44, 45, 46 |
| #19.f | GND to AC GND<br>Photo #47, 48, 49 |

PHOTO #32

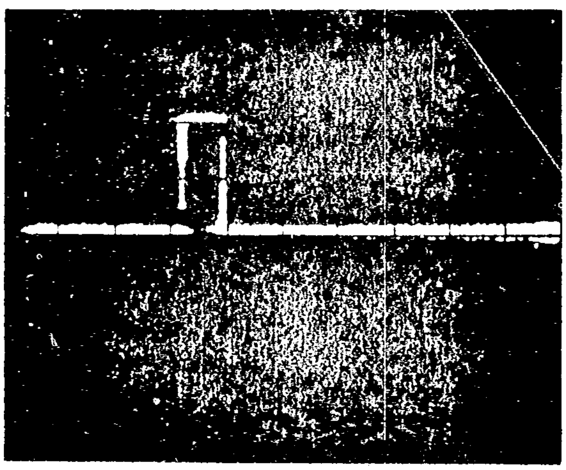


TB 109-6
TB 109-7 Signal

Vert. Gain: 5V/Div

Horiz. Time Base: 1 s/Div

PHOTO #33

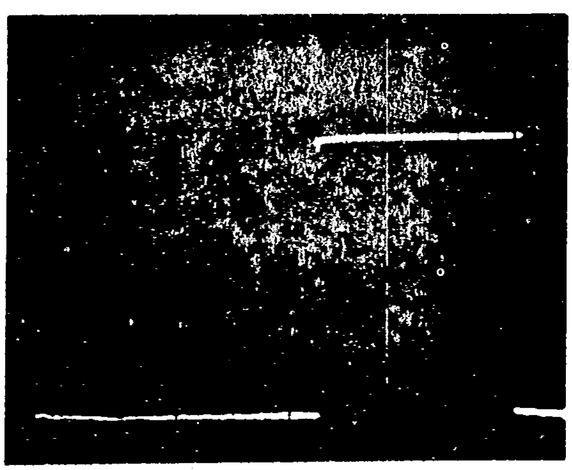


TB 109-6
TB 109-7 Signal

Vert. Gain: 5V/Div

Horiz. Time Base: 0.2s/Div

PHOTO #34

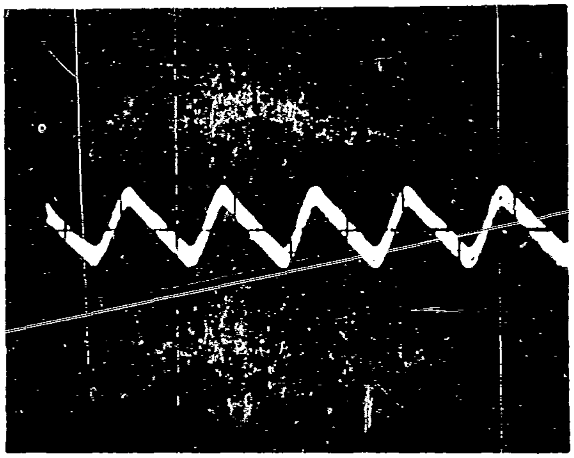


TB 109-6
TB 109-7 Signal

Vert. Gain: 2V/Div

Horiz. Time Base: 0.5s/Div

PHOTO #35

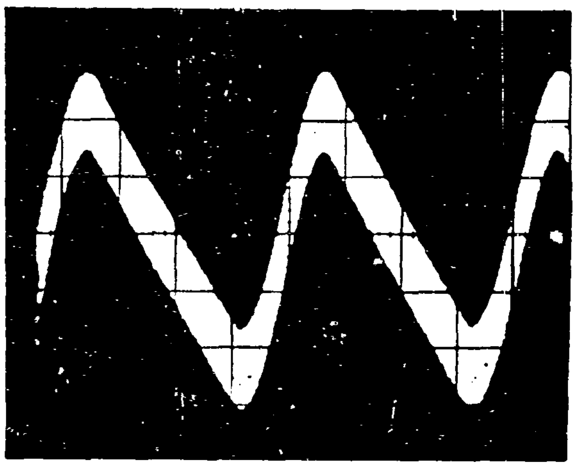


TB 109-1
TB 109-10 — Check Source

Vert. Gain: 0.2V/Div

Horiz. Time Base: 5 ms/Div

PHOTO #36

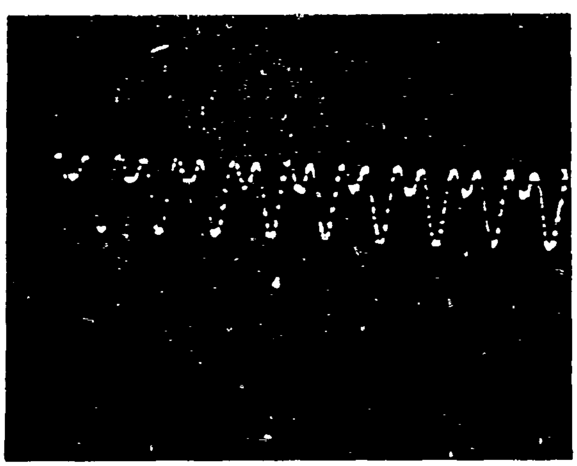


TB 109-1
TB 109-10 — Check Source

Vert. Gain: 50mV/Div

Horiz. Time Base: 2 ms/Div

PHOTO #37

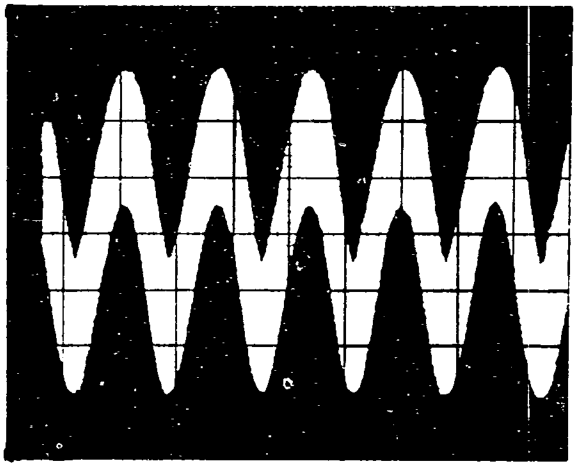


TB 109-1
TB 109-10 — Check Source

Vert. Gain: 50mV/Div

Horiz. Time Base: 50μs/Div

PHOTO #41

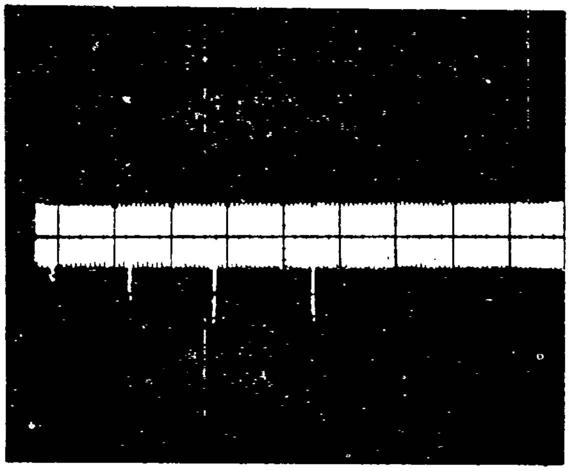


TB 109-5 ⎤
TB 109-10 ⎦ +600V

Vert. Gain: 20mV/Div

Horiz. Time Base: 10ms/Div

PHOTO #42

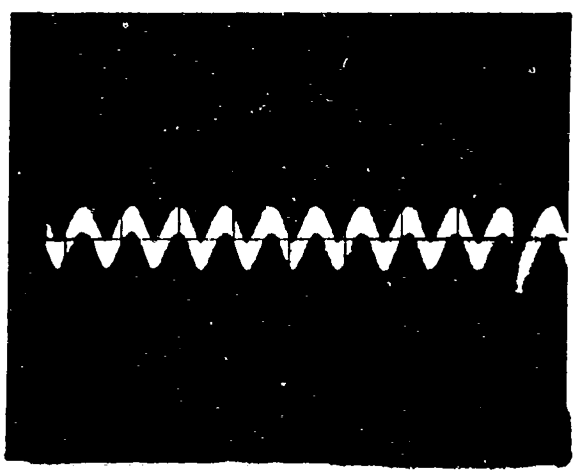


TB 109-5 ⎤
TB 109-10 ⎦ +600V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.2s/Div

PHOTO #43

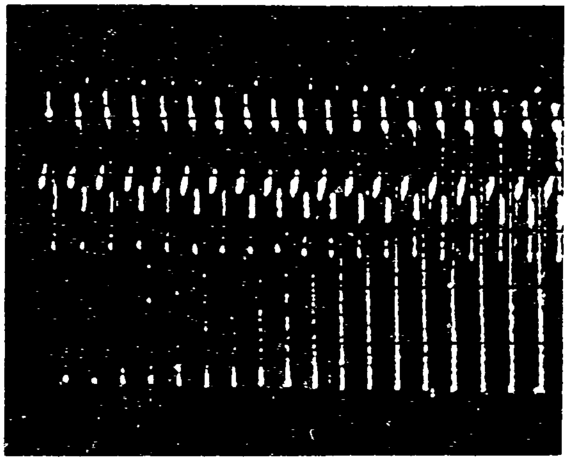


TB 109-5 ⎤
TB 109-10 ⎦ +600V

Vert. Gain: 100mV/Div

Horiz. Time Base: 20ms/Div

PHOTO #44

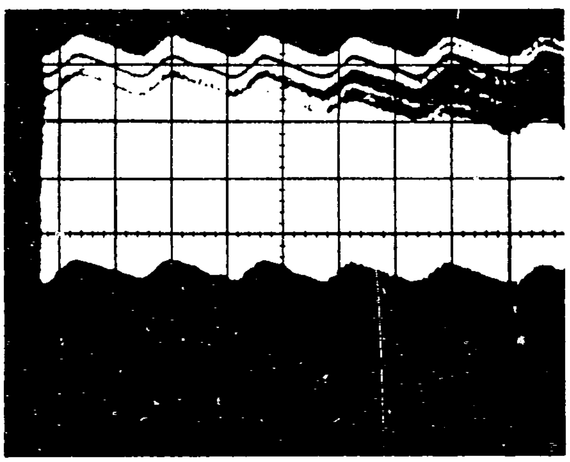


TB 109-8
TB 109-10 +10V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.1ms/Div

PHOTO #45

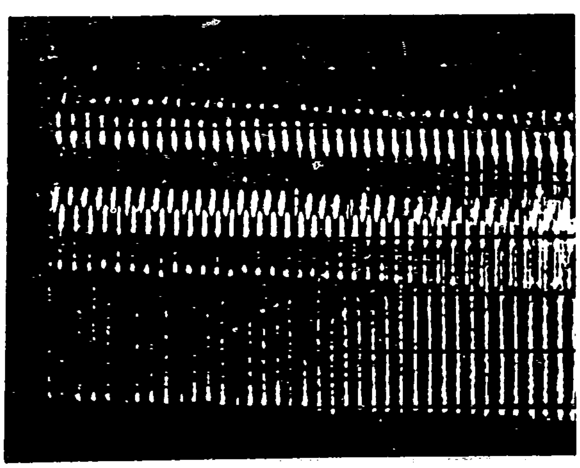


TB 109-8
TB 109-10 +10V

Vert. Gain: 50mV/Div

Horiz. Time Base: 5ms/Div

PHOTO #46

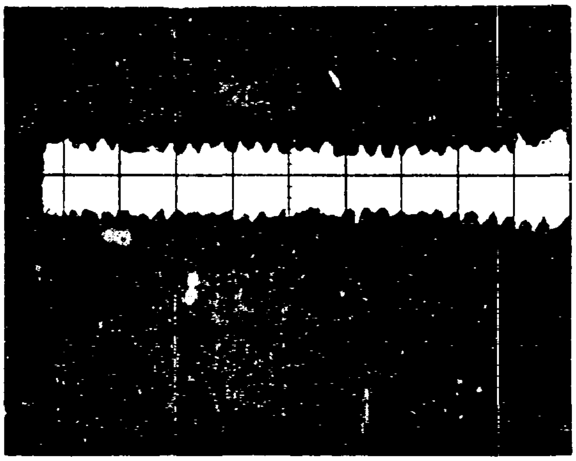


TB 109-8
TB 109-10 +10V

Vert. Gain: 20mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #47

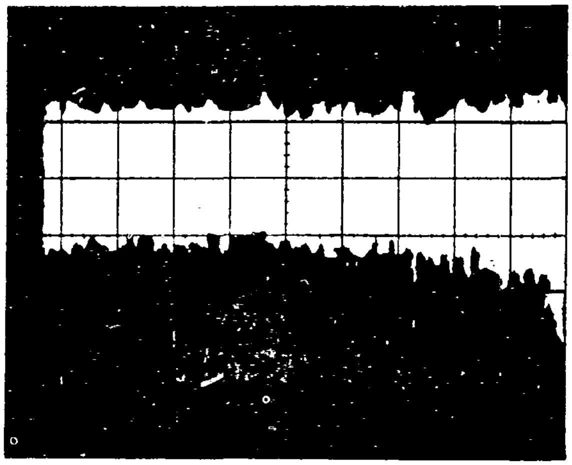


TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 5mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #48

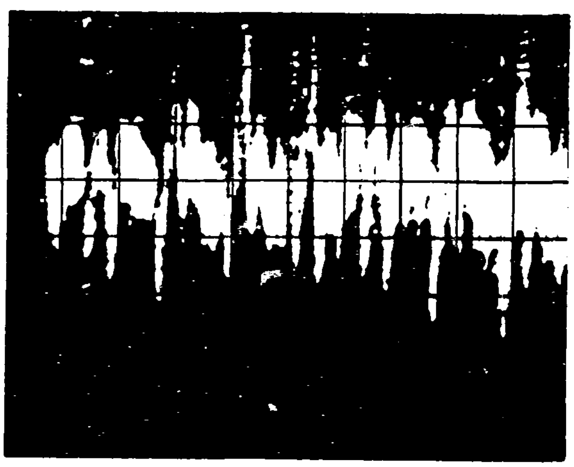


TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 2mV/Div

Horiz. Time Base: 0.2ms/Div

PHOTO #49



TB 109-10 ] GND
TB 501-27 ]

Vert. Gain: 2mV/Div

Horiz. Time Base: 50µs/Div

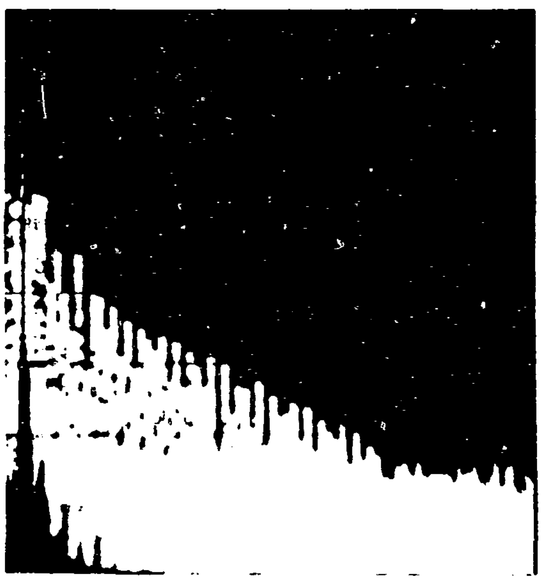


PHOTO #50

TB 109-8
TB 109-10 +10V

BW - 3KHz

Horiz. Scale: 200 KHz/Div

Scan Time: 100 ms/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

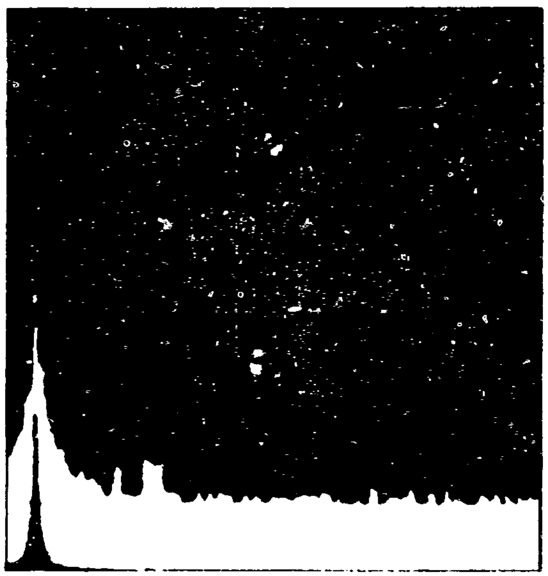


PHOTO #51

TB 109-6
TB 109-7 Signal

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time: - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

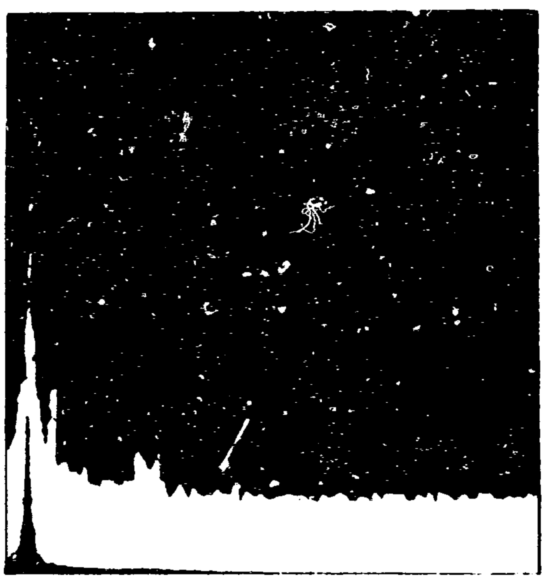


PHOTO #52

TB 109-5
TB 109-10 +600V

BW - 3 KHz

Horiz. Scale: 500 KHz/Div

Scan Time - 0.2 s/Div

Vert. Scale: 0 dB Ref; 10 dB/Div

Input attenuation: 40 dB

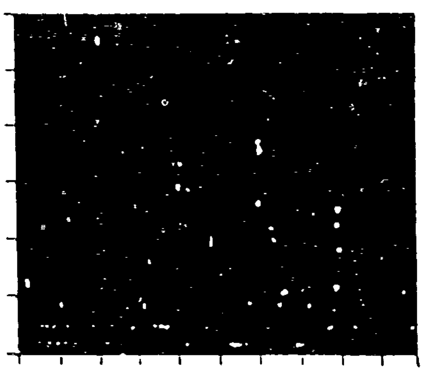



PHOTO #53

TB 109-5
TB 109-10
+600V

Range: 0 - 100 KHz

Vert. Scale: +20 dB Ref; 10 dB/Div

0.00260 RMS

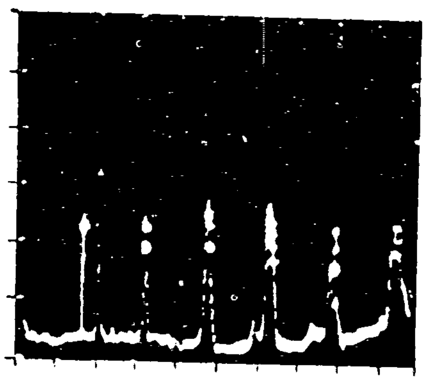


PHOTO #54

TB 109-6 ⎤
         ⎥ Signal
TB 109-7 ⎦

Range: 0 - 100 KHz

16 KHz Harmonics Intensified

(20 KHz Harmonics also present)

Vert. Scale: +20 dB Ref; 10 dB/Div

0.0332 RMS

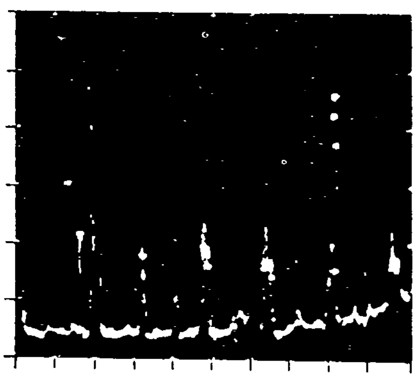


PHOTO #55

TB 109-8
TB 109-10
+10V

Range: 0 - 100 KHz

16 KHz Harmonics Intensified

(20 KHz Harmonics also present)

Vert. Scale: +20 dB Ref; 10 dB/Div

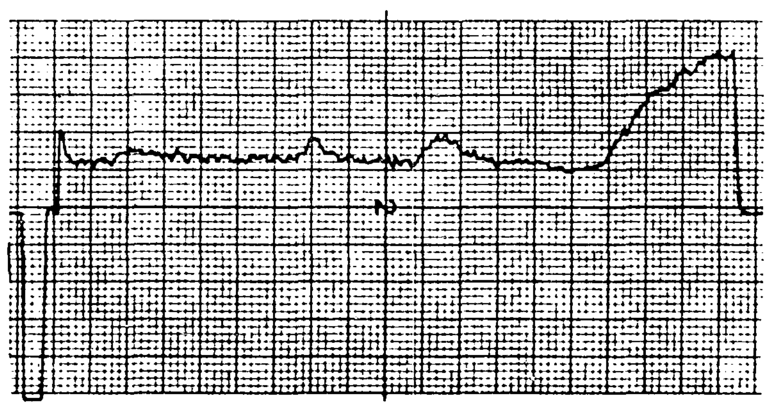
# SECTION A.5.5

# POST-REMOVAL TDR MEASUREMENTS ON CABLE

Test 34a - 1

From Blue to Orange

Checksource



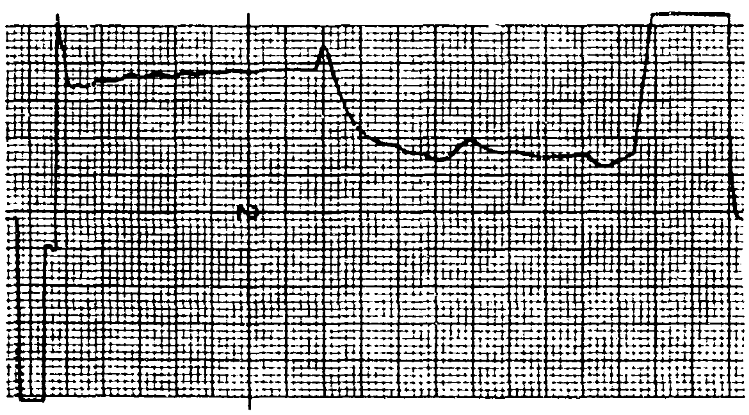
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.25V/Div, 500 m$\rho$/Div

Test 34b - 1

From RG 59/U Center to RG 59/U Shield

600V to Shield



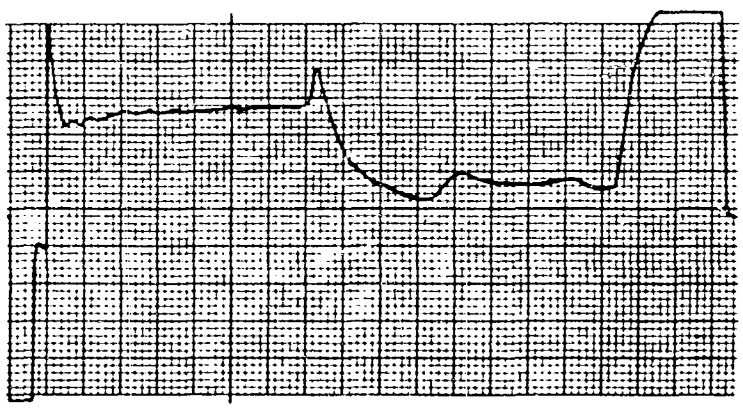
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mρ/Div

Test 34c - 1

From RG 58/U Center to RG 58/U Shield

Signal to Shield



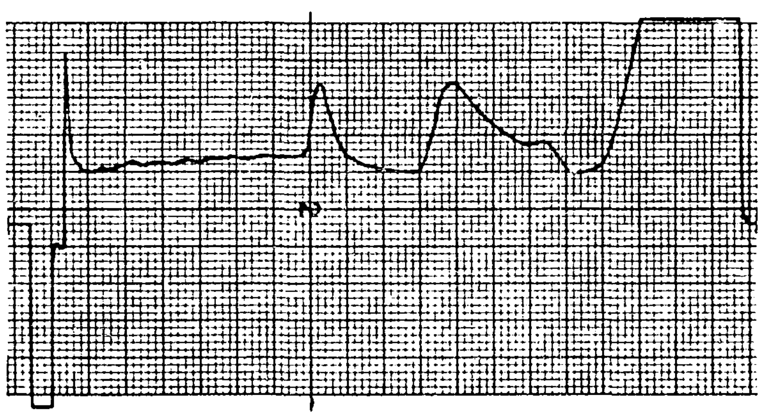
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mρ/Div

Test 34d - 1

From Red to Black

+10V to GND



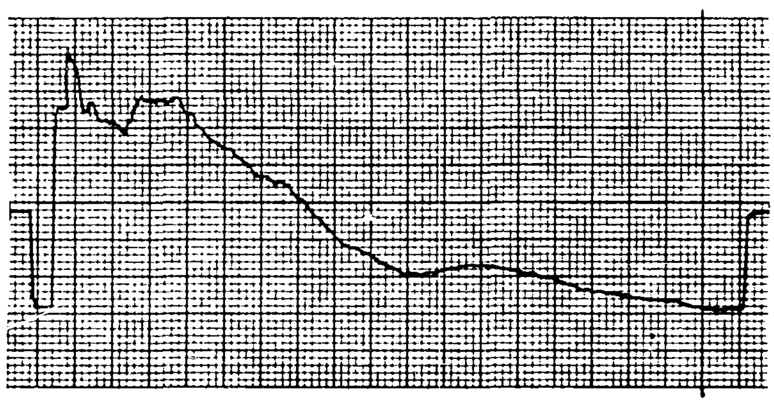
Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.10 V/Div; 500 mρ/Div

Test 34e - 1

From Black to TB109-10

GND to GND

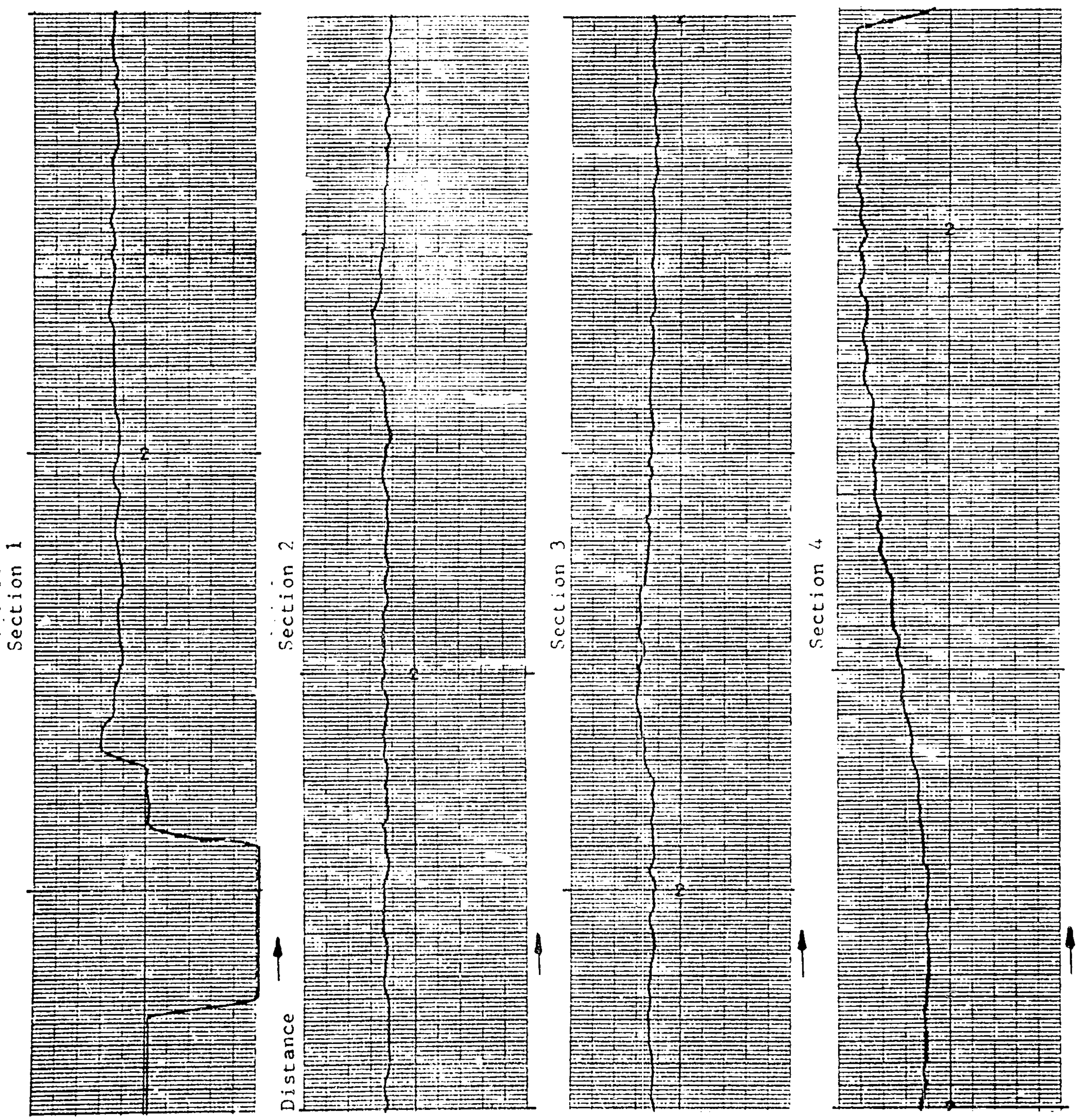


Horizontal Scale: 26.32 ft/Div

Vertical Scale: 0.25 V/Div; 500 mρ/Div

Test 34a - 2: From Blue to Orange - Checksource

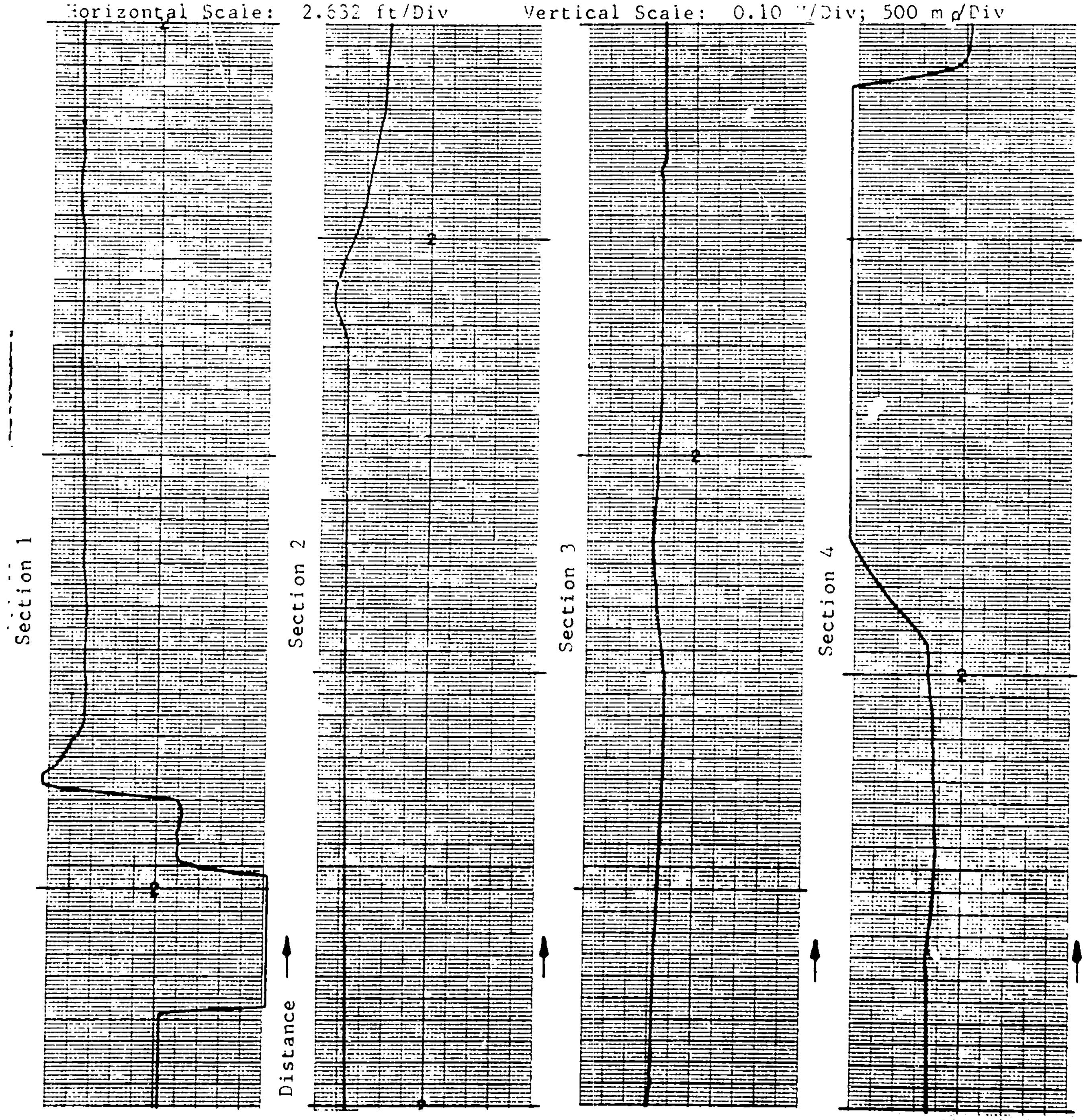
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.25 V/Div; 500 mp/Div



Test 34b - 2: From RG 59/U Center to RG 59/U Shield

600V to Shield

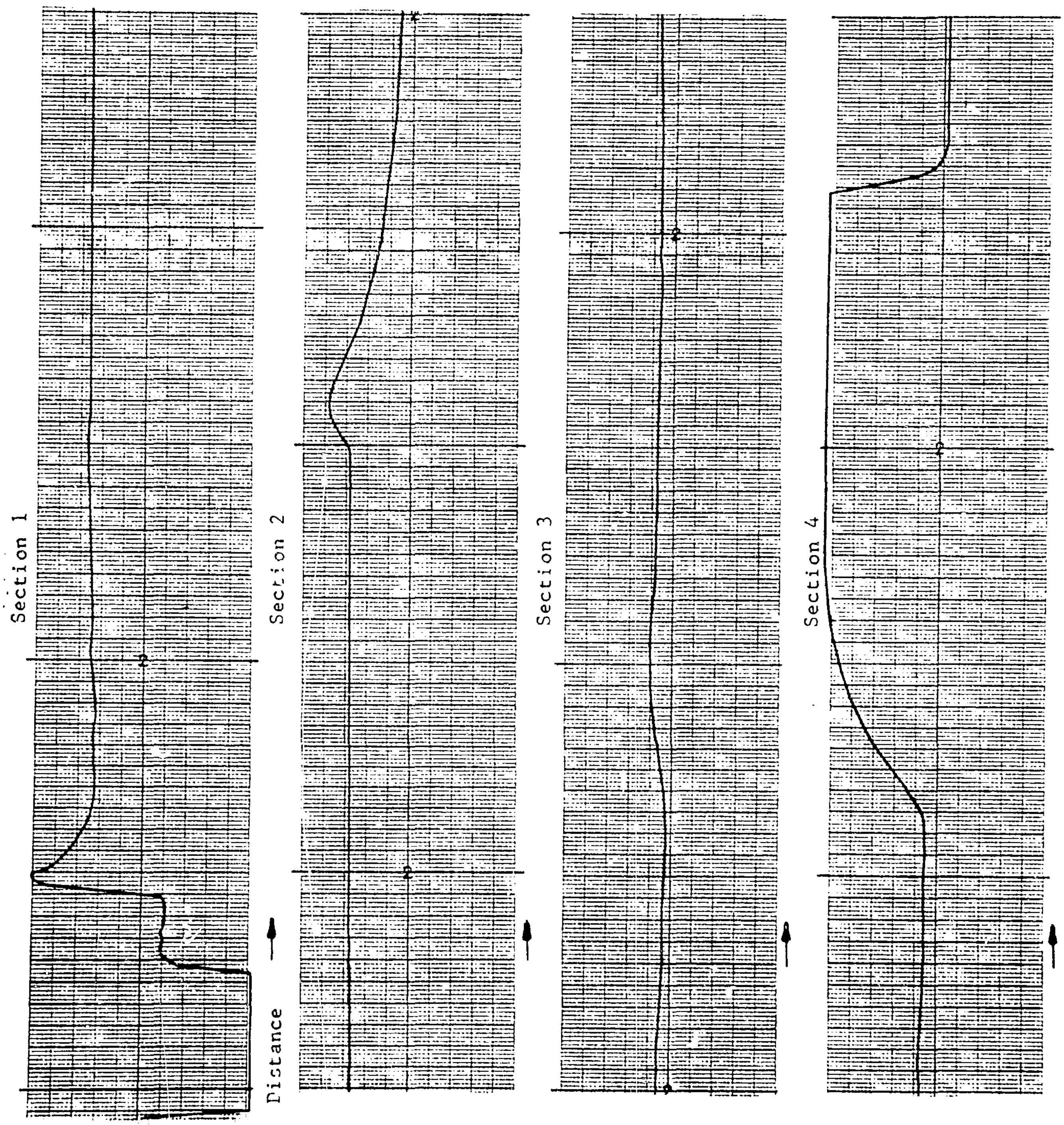
Horizontal Scale: 2.632 ft/Div    Vertical Scale: 0.10 V/Div; 500 mρ/Div



Test 34c - 2: From RG 58/U Center to RG 58/U Shield

Signal to Shield

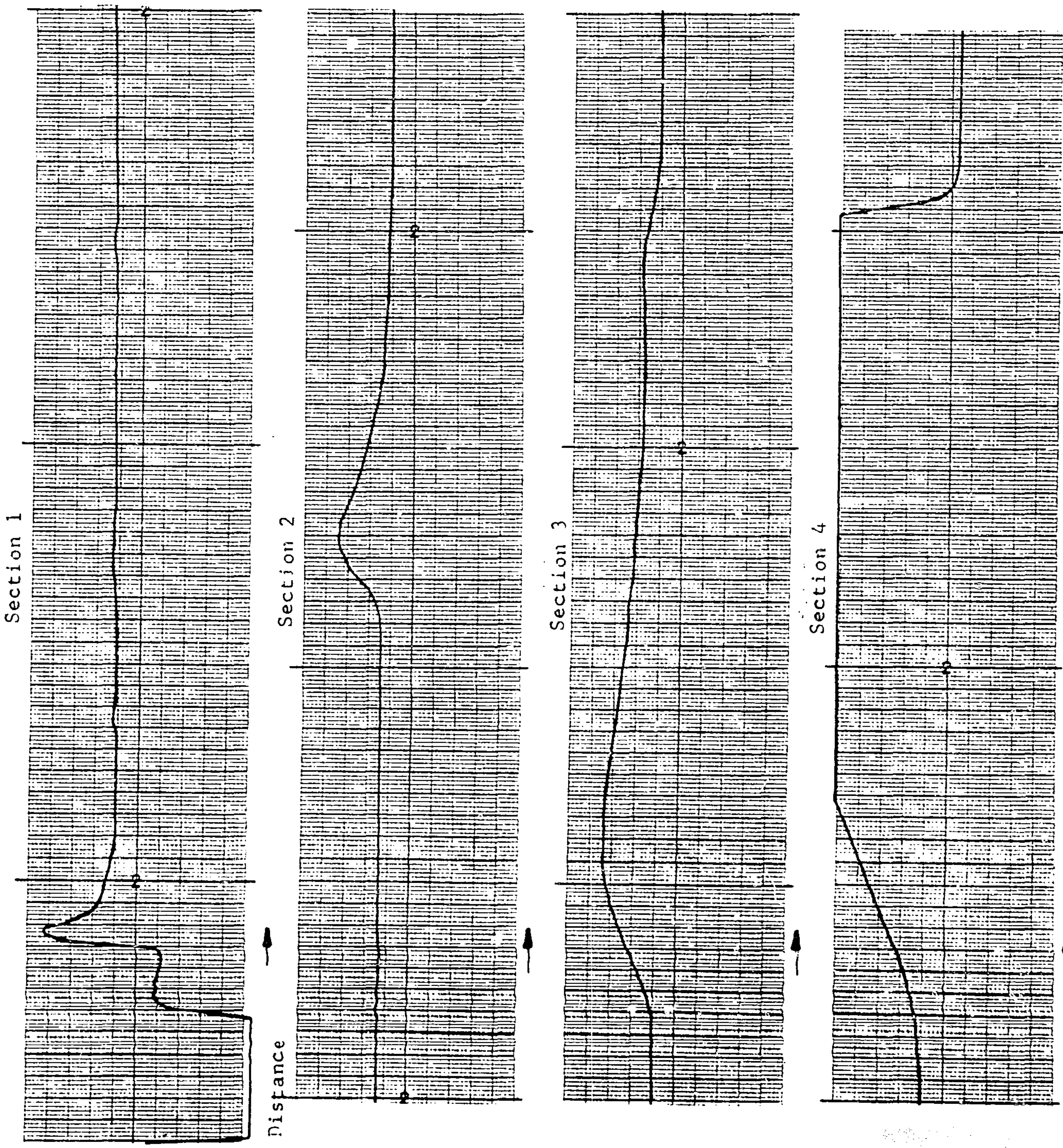
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10 V/Div; 500 mρ/Div



Test 34d - 2: From Red to Black

+10V to GND

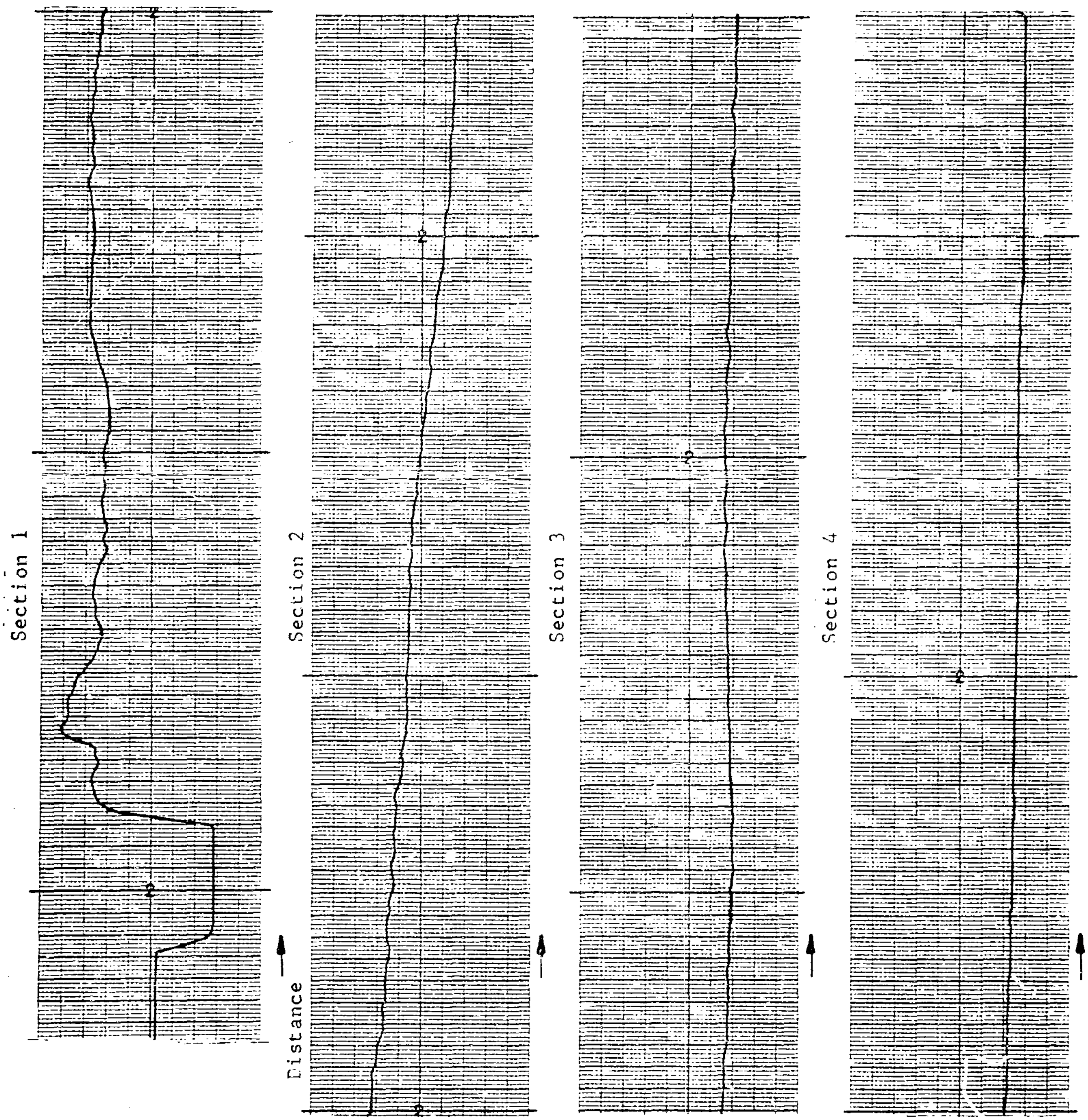
Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.10 V/Div; 500 m$\rho$/Div



Test 34e - 2: From Black to TB109-10

GND to GND

Horizontal Scale: 2.632 ft/Div Vertical Scale: 0.25 V/Div; 500 m ρ/Div



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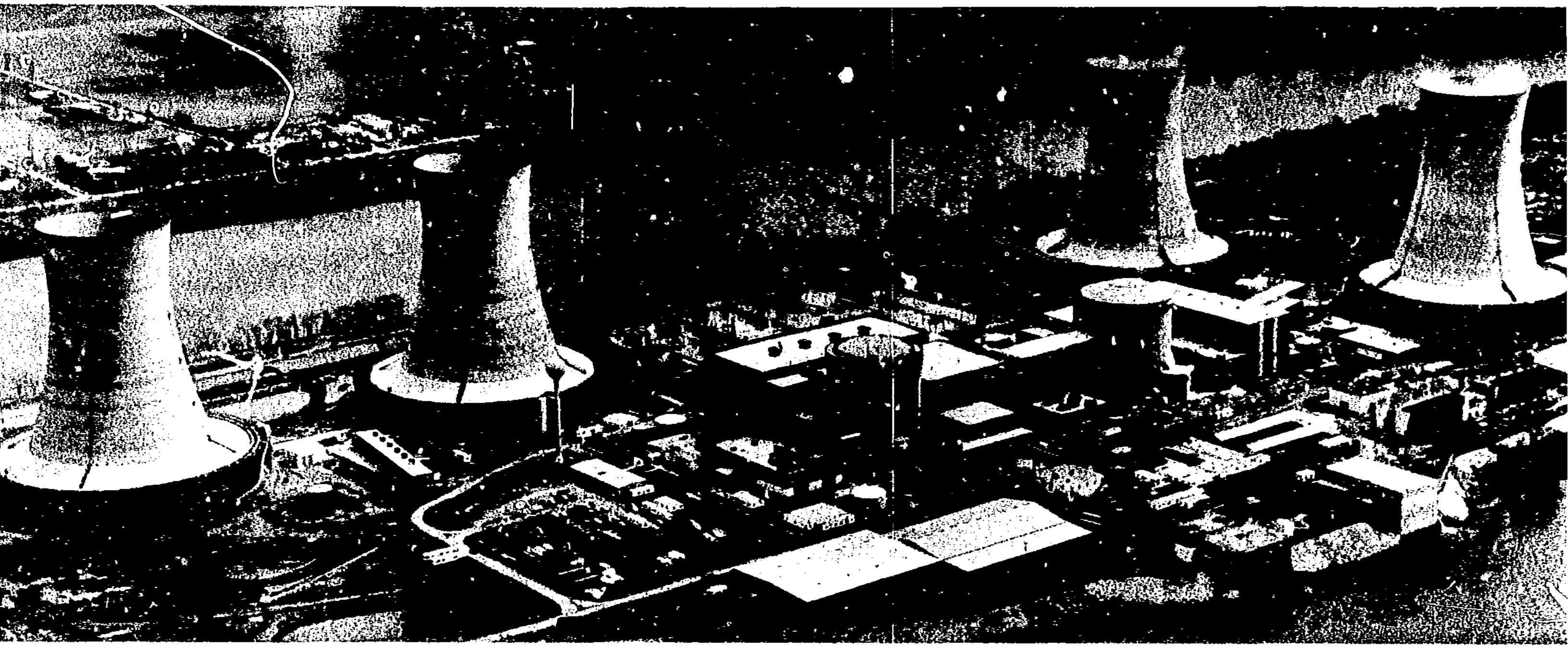

This is an informal report intended for use as a preliminary or working document

# GEND

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# FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-211

J. E. Jones
J. T. Smith
M. V. Mathis

U.S. Department of Energy
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-76ID01570

GEND-INF--017 Vol. 3

DE82 010046

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Volume III

# FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-211

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Technology for Energy Corporation

January 1982

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MGW

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# 1. INTRODUCTION

During and following the TMI-2 accident, a number of instruments failed or were suspected of providing erroneous readings. Because of this problem, industry concerns were focused upon the behavior of instrumentation under adverse conditions. To better understand failure mechanisms, the Technical Integration Office (TIO) contracted Technology for Energy Corporation (TEC) to perform field measurements on a set of selected instruments to determine current in-situ operating characteristics. For some instruments, these measurements were to be performed prior to removal (and replacement with new instruments) in order to have a cross reference with post removal observations.

This report provides the information gathered by TEC on the area radiation monitor HP-R-211. This detector was located at 305 feet elevation, just inside the entry hatch (ante-room) used during initial entries into containment. This instrument consisted of a Victoreen Model 857-2 detector assembly connected to a Victoreen Model 856-2 panel alarm and approximately 520 feet of interconnecting cable. This instrument was believed to have failed due to low radiation level indications and due to a lack of response to the manually activated checksource in the detector. As a result of this failure, the detector was a candidate for early replacement to provide long-term radiation monitoring capability inside containment at the entry hatch.

## 2. INSTRUMENT LOCATION, CABLING, AND TERMINATIONS

A review of appropriate drawings from Victoreen and Burns & Roe (itemized in the Appendix in the measurement procedure, page A-5) resulted in the composite electrical diagram shown in Figure 2-1. From this information, Table 2-1 gives a list of the appropriate termination points for performing measurements in the Control Room in Cabinet 12. Also noted in Figure 2-1 are the cable lengths pulled during instrument installation (before final trimming) between each termination and/or junction point.

The detector assembly is a Victoreen Model 857-2 which is shown in Figure 2-2 along with required interfacing connections to the readout module. Figure 2-3 shows the functional layout of the detector and associated readout module. This assembly is a "medium range" device with a range of 0.1 to $10^4$ mR/hr. An electrical diagram of the detector circuit is shown in Figure 2-4. As shown in Figure 2-1, the circuit is somewhat complicated by the presence of a remote alarm/meter which is used as a local indication of the radiation levels inside the entry hatch.

Since measurements were being made in the control room, there was no way to remove the effect of the remote meter (attached to the signal line) from the observed instrument response. However, since the remote meter was located outside containment, it did not experience severe operating environments and thus was not considered to present any measurement problems. Similarly, the Model 856-2 Readout Module, located in the control room, was not specifically considered to be a source of instrumentation problems except in its function of supplying power to the detector assembly.

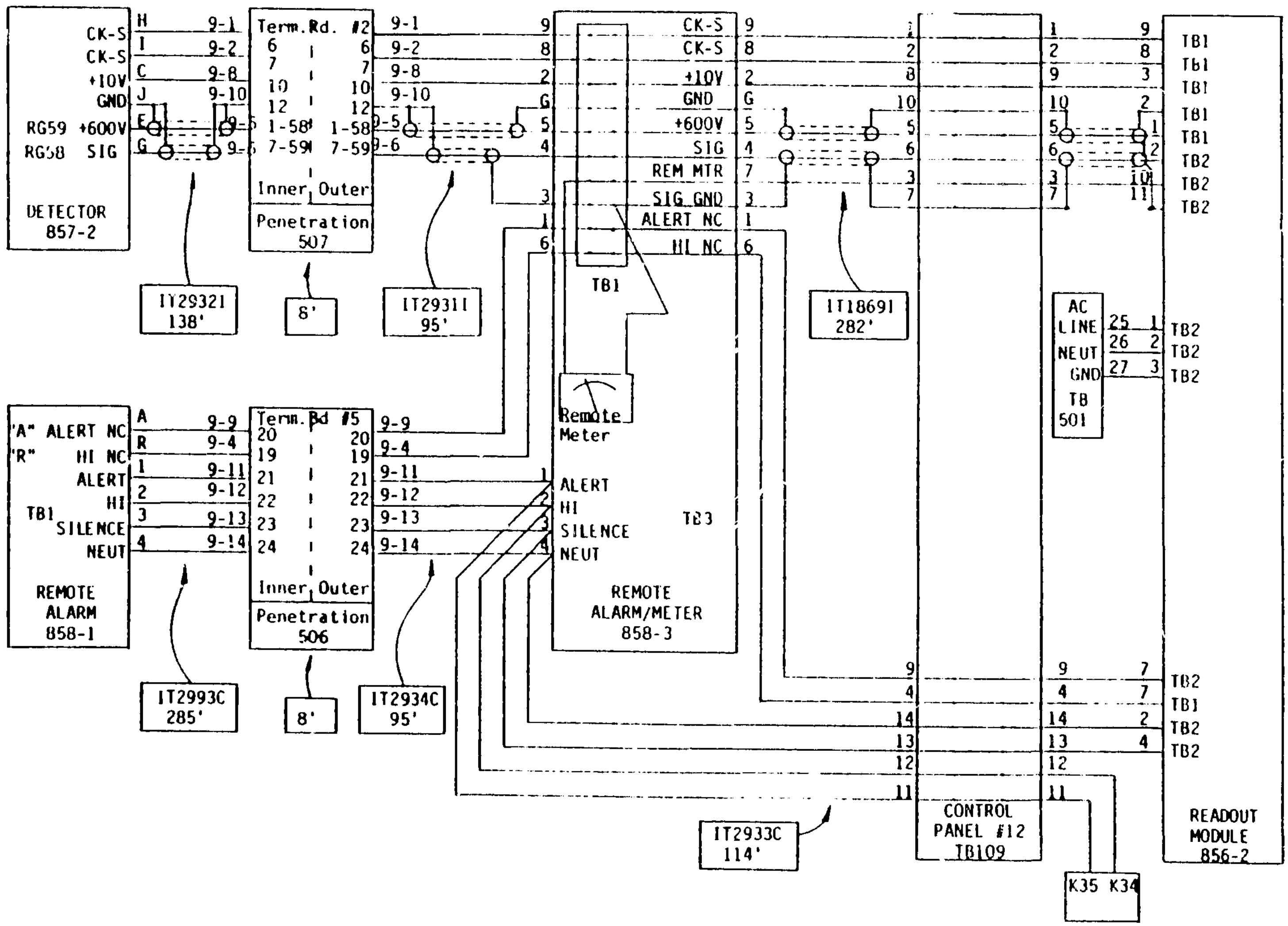



Figure 2-1. HP-R-211 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-211 MEASUREMENTS

| Signal | Cabinet 12 Identification* |
|---|---|
| +10V Power Supply | TB109-8 |
| +600V High Voltage | TB109-5 |
| Signal Out | TB109-6 |
| Ground | TB109-10 |
| CS** | TB109-1 |
| CS** | TB109-2 |

*From cable IT2931I

**CS = Checksource coil positive and return contacts (exact identification not necessary).

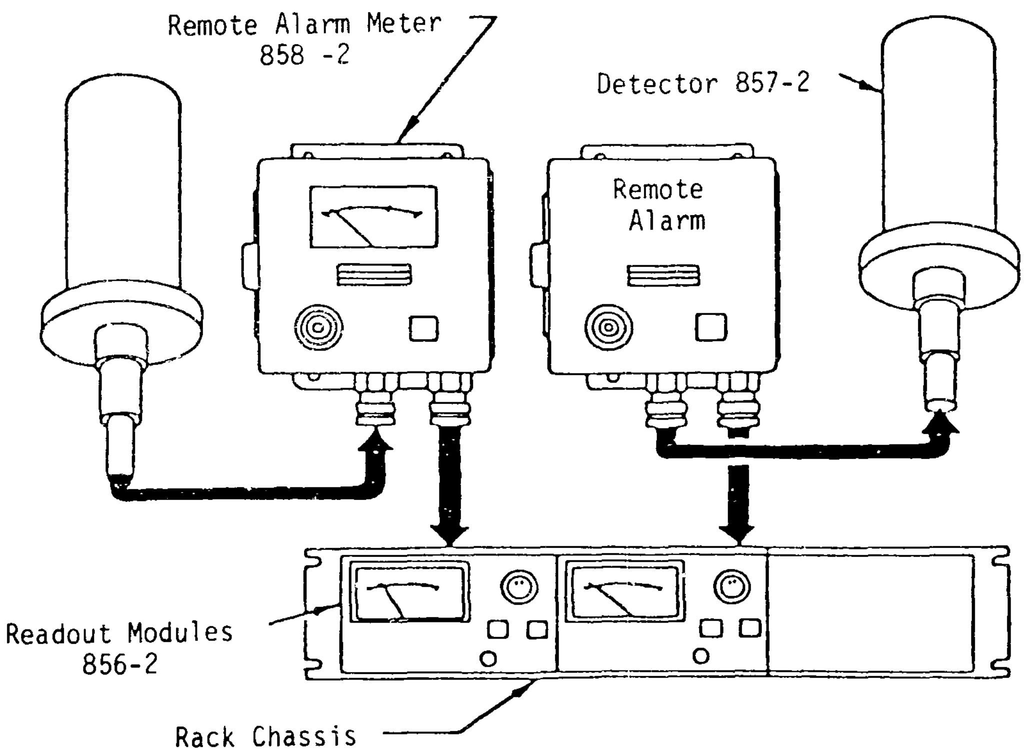



Figure 2-2. Sketch of Instrumentation for HP-R-211.

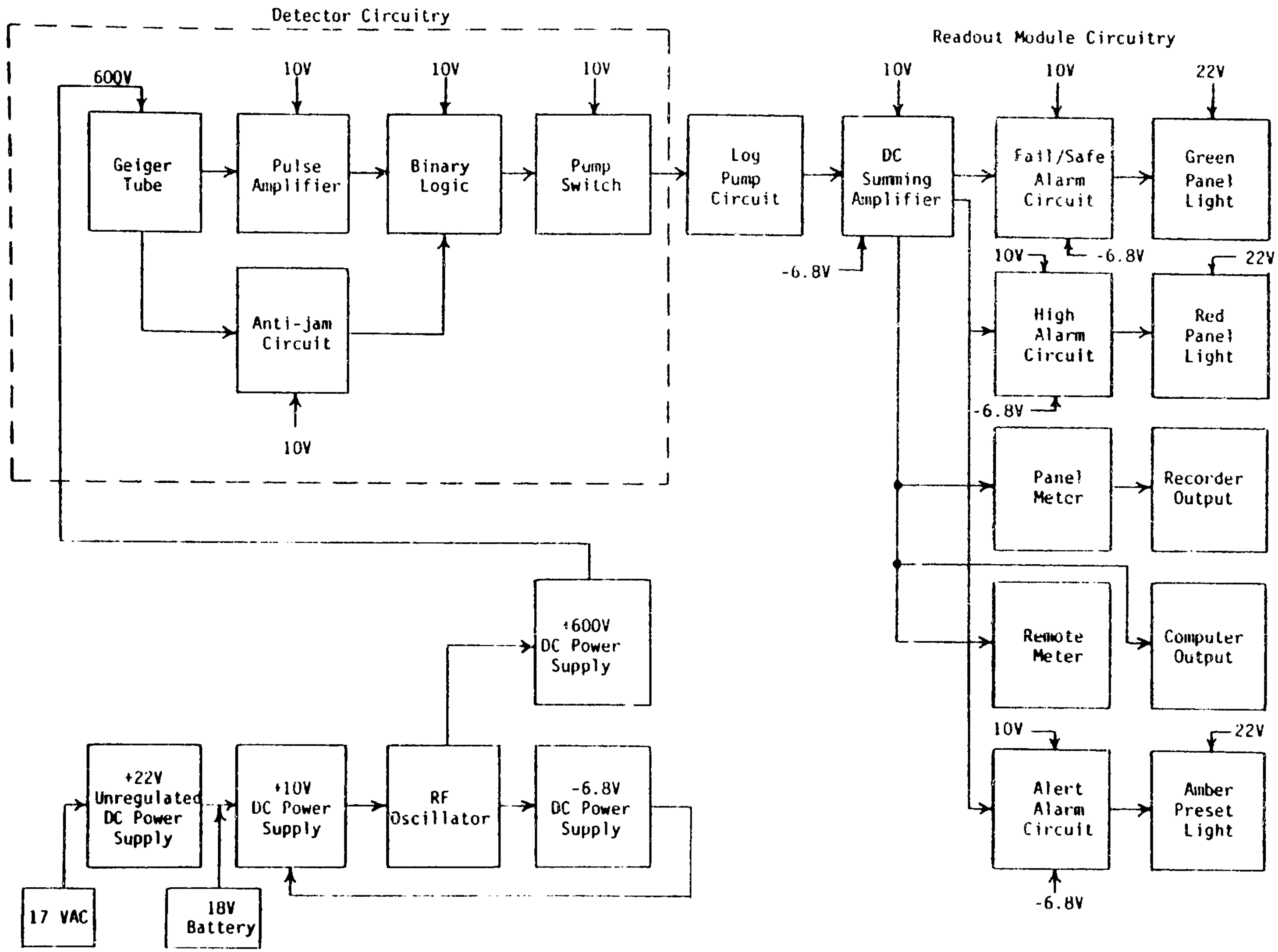



Figure 2-3 Functional Layout of Detector and Readout Module.

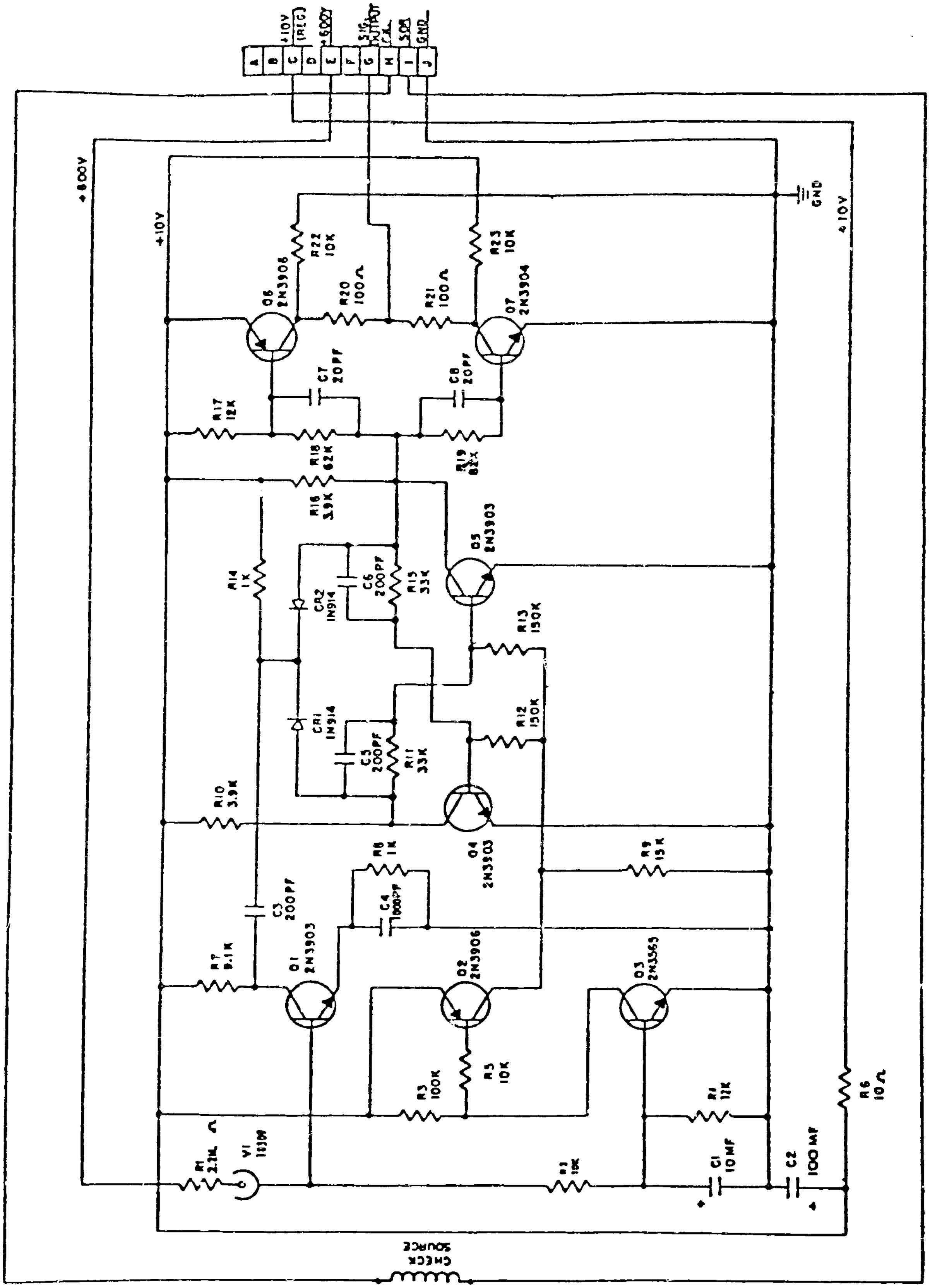



Figure 2.4 Electrical Circuit of Detector Card.

## 3. PREPARATION OF MEASUREMENT PROCEDURES

As a result of generating the composite electrical diagram and from a review of the Victoreen Area Monitor Operation Manual, the major types of measurements to be performed were identified as

1. Determine as-found condition of Readout Module and Remote Meter and record signal output

2. Perform passive measurements (i.e., passively monitor signals) on each electrical connection consisting of time domain waveforms, very-high frequency spectrum analysis (i.e., MHz region), and frequency spectra below 100 kHz

3. Perform resistance, capacitance, impedance, and Time Domain Reflectometry (TDR) active measurements (i.e., actively introducing a test signal).

These measurements were designed to verify the operation of the Readout Module (especially the power supplies) and the Remote Meter/Alarm. The focus of the measurement was on the detector assembly, cabling, and terminations/connections to the assembly. The Appendix contains the detailed procedure which was followed during the measurement program, and a summary of measurements is presented in the next section.

# 4. MEASUREMENTS

Since HP-R-211 was a candidate for removal and possible replacement, measurements were attempted at five different conditions:

1. Laboratory measurements on a spare detector and readout module assembly
2. Pre-insertion detector pin measurements on two spares
3. Measurements on the installed detector-readout assembly
4. Measurements with a replacement detector installed at the remote meter location
5. Attempted measurements on the newly installed detector (only TDR cable measurements were possible).

Each set of measurements is described in the following sections.

## 4.1 LABORATORY MEASUREMENTS (MOCK-UP)

Prior to performing the measurements on the installed instrumentation, a preliminary set of measurements were taken on a spare detector and readout module assembly. Pages A-3 to A-16 in the Appendix are the actual field data sheets for the measurements. A summary of the important data is presented in Table 4-1. Of equal importance to the measurements on the detector were the calibration data obtained on the equipment to be used for the field tests. ges A-17 to A-22 show the results of these measurements with the resulting equipment calibration (i.e., conversion values) data.

Table 4-1

SUMMARY OF MOCK-UP MEASUREMENTS
(DETECTOR RESISTANCES)

| Measurement Points | Polarity + | Polarity - |
|---|---|---|
| Checksource (+)<br>Checksource (-) | 30.4 ohms | 30.4 ohms |
| Signal in<br>Shield | 8.85 | 7.23 |
| Signal in<br>+10V | --- | --- |
| Shield<br>+10V | 7.47 | 11.90 |

Notes:
(a) All values in ohms x $10^3$ unless otherwise indicated

(b) First signal to positive terminal and second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM on $20 \times 10^3$ ohm scale.

## 4.2 PRE-INSERTION DETECTOR PIN MEASUREMENTS

Prior to possible insertion into containment for replacement of HP-R-211, measurements were made on two detector connector pins to determine a typical range of normal values for resistances. These measurements were carried out on two different Model 857-2 detectors, serial numbers 111 and 1405. Table 4-2 shows the data obtained from these pin measurements which was used for later comparison to the data obtained from the HP-R-211 assembly. Note that there is only a small variation in measured values between the detectors and that the change in resistances with polarity is the result of active components (i.e., transistors) in the detector circuitry.

## 4.3 INSTALLED DETECTOR-READOUT MEASUREMENTS

Measurements were also performed on the HP-R-211 assembly in its as-found condition. The field data sheets for these measurements are shown in the Appendix on pages A-23 to A-41. When measurements began, the local and remote meters were indicating 1.5 and 3.5 mR/hr, respectively. Prior to performing further measurements, a recording of the Signal Out line was made on an FM tape recorder using AC coupling to remove an offset of approximately 7V in the signal. Following this recording, passive measurements were made on certain signals with the following results:

(a) 10V Power Supply @ 9.4V

(b) Signal DC Voltage @ 7.5V with no checksource

@ 7.5V with checksource

Table 4-2

SUMMARY OF DETECTOR PIN RESISTANCE MEASUREMENTS

| Measurement Points | Detector #111 Polarity + | Detector #111 Polarity - | Detector #1405 Polarity + | Detector #1405 Polarity - |
|---|---|---|---|---|
| Checksource (+)<br>Checksource (-) | --- | --- | 30 ohms | 30 ohms |
| Signal In<br>Shield | 8.77 | 7.34 | 8.79 | 7.16 |
| Signal In<br>+10V | 8.27 | 6.56 | 8.38 | 6.84 |
| Shield<br>+10V | 7.44 | 11.77 | 7.37 | 11.84 |

Notes: (a) All values are in ohms x $10^3$ unless otherwise indicated

(b) First signal to positive terminal; second to negative is considered Polarity +

(c) All measurements made with a Keithley 177 DVM or $20x10^3$ ohm scale.

(c) 600V Power Supply @ 605V

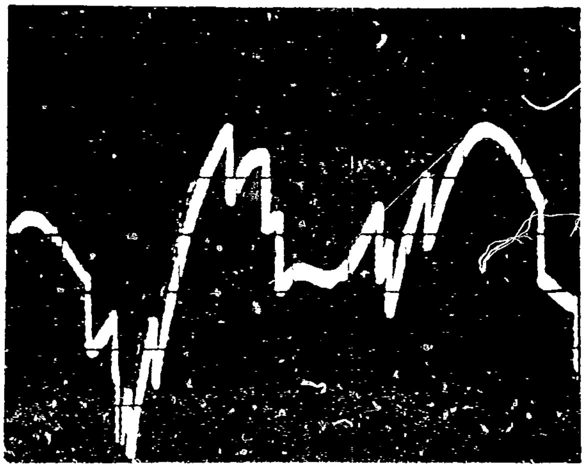
(d) Checksource Current @ 13 ma.

These measurements indicated that the 10V power supply was somewhat low, that the signal did not significantly change when the checksource was applied, that there was an offset in the signal line (detected during earlier recording), and that the 600V supply and checksource coil were operating correctly.

A series of time plots of all instrument line responses were obtained by photographing the trace from a storage oscilloscope. Figures 4-1 to 4-3 show typical results of these measurements for the 600V supply, signal, and 10V supply, respectively. The complete set of photographs is shown in the Appendix on pages A-79 to A-86. Frequency domain spectrum plots were also obtained for each signal over both a 0-5 MHz band and a 0-100 kHz band and the complete set of data can be found on pages A-87 to A-92. Figures 4-4 to 4-6 show the 0-100 kHz plots of the signal spectra, but not the high-frequency band, since little information is present at those frequencies. From these measurements of the waveforms, the following summary is obtained:

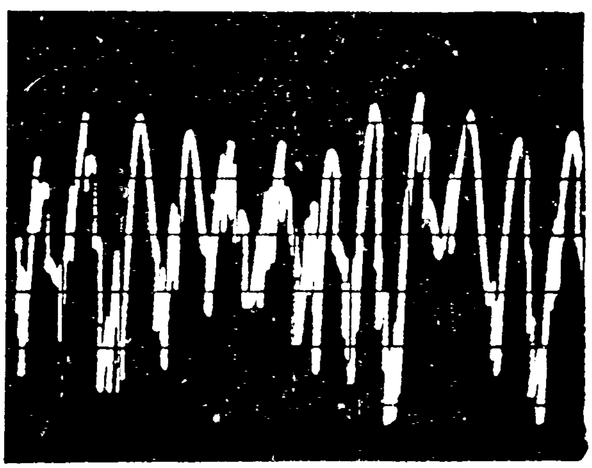
(1) 600V supply: 1V P-P @ 120 Hz present
small 20 kHz and harmonics
small 95 kHz present
random pulses present (see 1/f spectrum)
at lower frequencies

(2) Signal : 3.4V P-P random pulses present
small 32 kHz and harmonics present



a) Vertical Scale
0.2V/Div

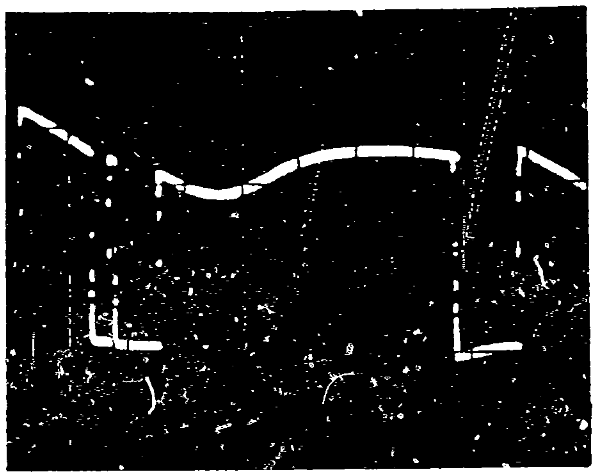
Horizontal Scale
2 ms/Div



b) Vertical Scale
0.2V/Div

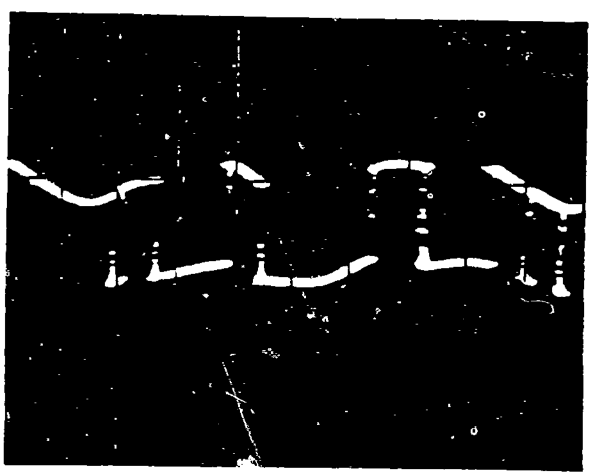
Horizontal Scale
10 ms/Div

Figure 4-1. Typical AC Fluctuations Present on 600 V Supply.



a) Vertical Scale
1V/Div

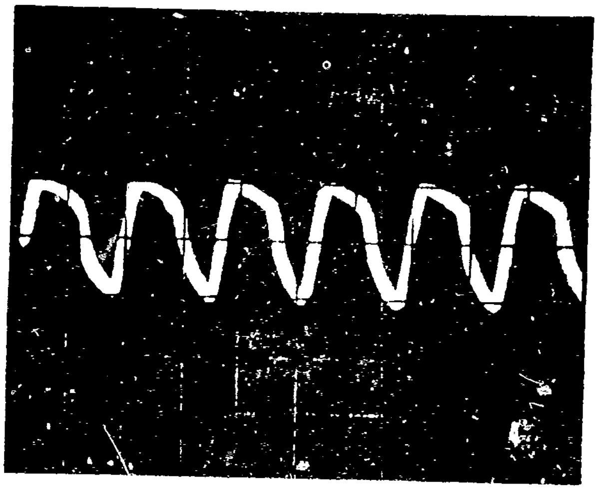
Horizontal Scale
1 ms/Div



b) Vertical Scale
1V/Div

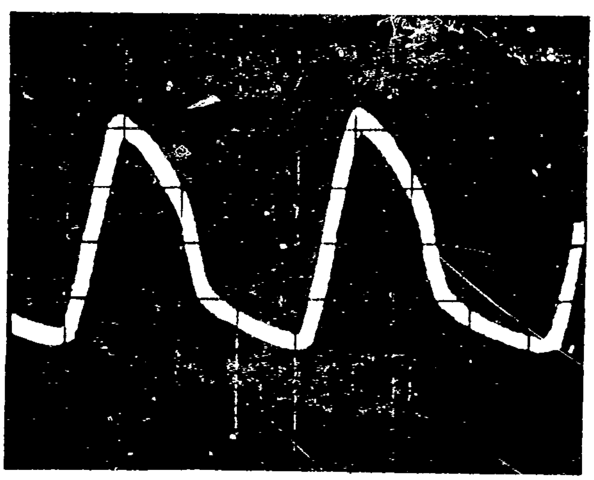
Horizontal Scale
2 ms/Div

Figure 4-2. Typical Output Signal.



a) Vertical Scale
1V/Div

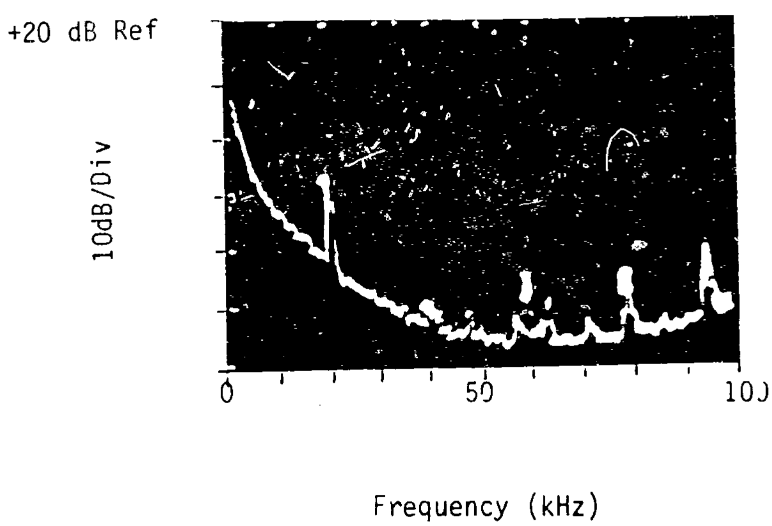
Horizontal Scale
5 ms/Div



b) Vertical Scale
0.5V/Div

Horizontal Scale
2 ms/Div

Figure 4-3. Typical Fluctuations on the 10 Volt Power Supply.

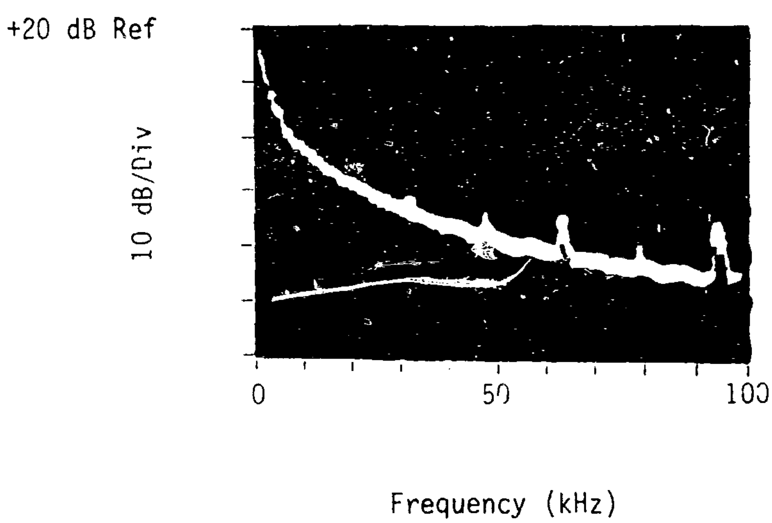



Note:

20 kHz Harmonics Intensified

AC RMS = 0.109 Volts

Figure 4-4. Frequency Spectra for 600 Volt Power Supply.

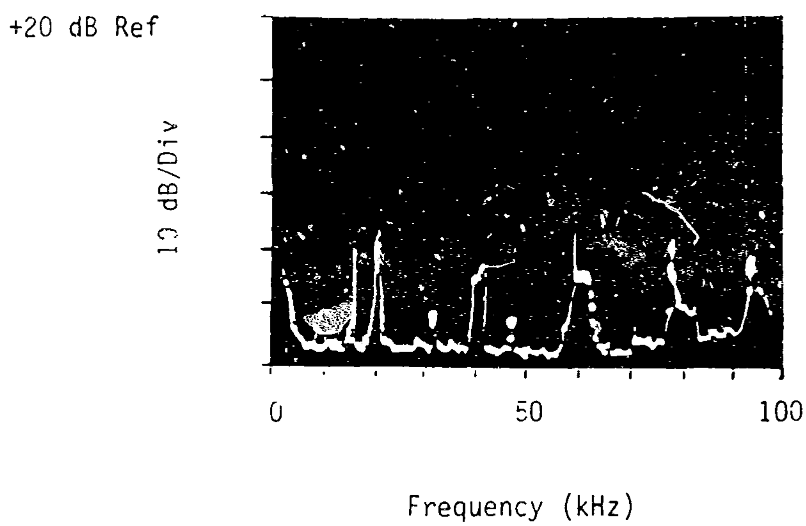



Note:

32 kHz Harmonics intensified

AC RMS = 1.35 Volts

Figure 4-5. Frequency Spectra for Output Signal.



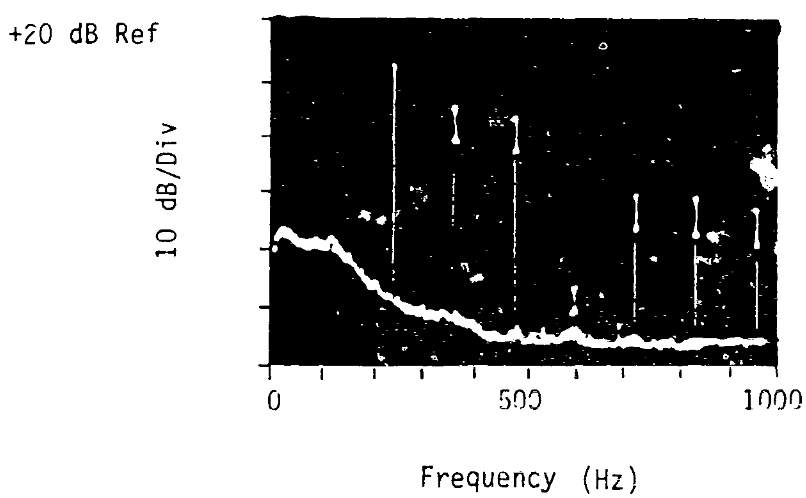

a) 0-100 kHz Range

Note:

16 kHz Harmonics Intensified

20 kHz Harmonics Present

AC RMS = 0.301 Volts




b) 0-1 Hz Range

Note:

120 Hz Harmonics Intensified

AC RMS = 0.712 Volts

Figure 4-6. Frequency Spectra for 10 Volt Power Supply.

(3) 10V supply : 2V P-P @ 120 Hz present
small 16 kHz and harmonics present
small 20 kHz and harmonics present.

This data again indicates a problem in the 10V supply due to the excessive 120 Hz AC present. Another problem is obvious in the small amplitude of the Signal pulses since they should span approximately 10V.

After completion of these measurements, the normal instrument calibration procedure was performed on the readout module electronics. The raw data sheets from the calibration are given on pages A-62 and A-63.

Application of the calibration procedures resulted in replacement of a capacitor in the +22V supply in the readout module, which directly feeds the 10V supply. This capacitor was the cause of the low supply voltage and probably caused the excessive 120 Hz fluctuations by allowing the rectified AC line signal to pass through. After the calibration, all voltages were restored to normal values.

After calibration of the readout module, power was removed from the instrument and the field cable links were opened between the detector and the readout module. A series of capacitance and impedance measurements were made at the field side (directly to detector) of the terminal blocks. The data obtained from this test is erratic due to the presence of long cables and active components in the detector, but may be found on page A-39 of the Appendix.

The integrity of the cable between the control room cabinet and the detector was then tested by performing TDR measurements. Figure 4-7 shows a typical TDR result for the Signal Out line with inflection points identified, and Table 4-3 lists the inflection points for all lines measured. Notice that there is some scatter in the predicted location of electrical interfaces, but this is not unexpected when using TDR measurements. A complete set of TDR traces for all cables can be found in the Appendix on pages A-94 to A-107.

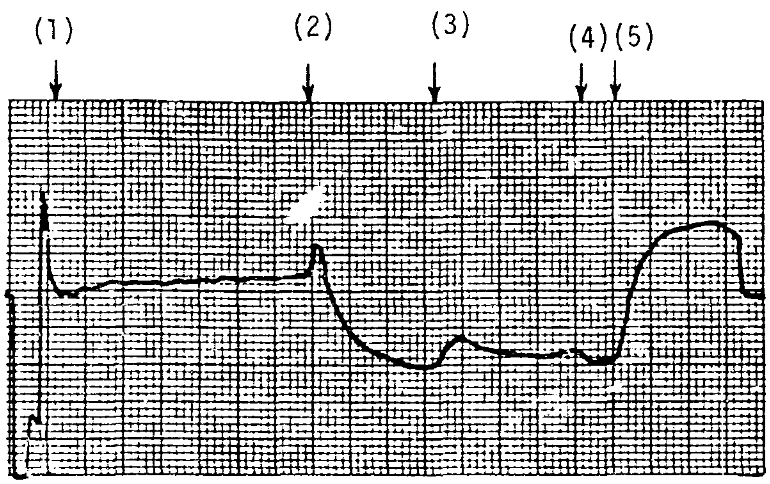
Upon completion of the TDR measurements, resistance measurements were performed on all combinations of signal lines at the terminal block. Note that this measurement is different from the detector pin measurements due to the length of cabling between the detector and the terminal block. However, this effect should be small (as confirmed by TDR data) and results should be comparable to the data taken previously. Table 4-4 lists the important measurements and a complete list can be found on page A-41.

## 4.4 MEASUREMENTS FOLLOWING REMOTE INSTALLATION OF NEW DETECTOR

Following the completion of measurements on the installed HP-R-211 system, a replacement model 887-2 detector (serial # 111) was installed by removing connections to the containment detector at the ante-room (remote) junctions. Before proceeding with measurements, the normal field calibration was performed on the detector-readout system using a calibration source. An adjustment to change the meter readouts upward by approximately a factor of two was needed, which is not unusual for expected variations with a new detector. The TMI calibration data sheets are given in the Appendix on pages A-64 to A-67.

Legend

(1) End of connecting cable & terminal
(2) Terminal block R increase
(3) Terminal block R increase
(4) Start of reduced R cable
(5) End of cable




Horizontal Scale:
26.3 ft/Div

Vertical Scale:
0.1 V/Div
(500 mρ/Div)

Figure 4.7 TDR Results of Signal Out Cable.

Table 4-3

SUMMARY OF TDR INFLECTION POINTS

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| Checksource | 163 | Increased R point | terminal block |
| | 253 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 379 | Large R increase | checksource coil |
| +600V (RG59) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 268 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 405 | Large R increase | detector circuitry |
| Signal (RG58) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 263 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 395 | Large R increase | detector circuitry |

Table 4-3 (Continued)

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| +10V | 163 | Increased R point | terminal block |
| | 242 | Increased R point | terminal block |
| | 342-358 | Slight R decrease | ? |
| | 379 | Large R increase | detector circuitry |
| Signal (RG58) with terminal block added | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 363 | Increased R point | terminal block |
| | 384 | Slight continuous R decrease | ? |
| | 405 | Large R increase | detector circuitry |

*TDR to terminal block test cable (10 ft) not included in distance.

**R is the abbreviation for resistance.

Table 4-4

RESISTANCE DATA FROM HP-R-211

| Measurement Points | Polarity + | Polarity - |
|---|---|---|
| Checksource (+)<br>Checksource (-) | 40.2 ohms | 40.2 ohms |
| Signal in<br>Shield | 8.62 | 6.53 |
| Signal in<br>+10V | 305 ohms | 305 ohms |
| Shield<br>+10V | 6.47 | 8.59 |

Notes: (a) All values in ohms x $10^3$ unless otherwise indicated.

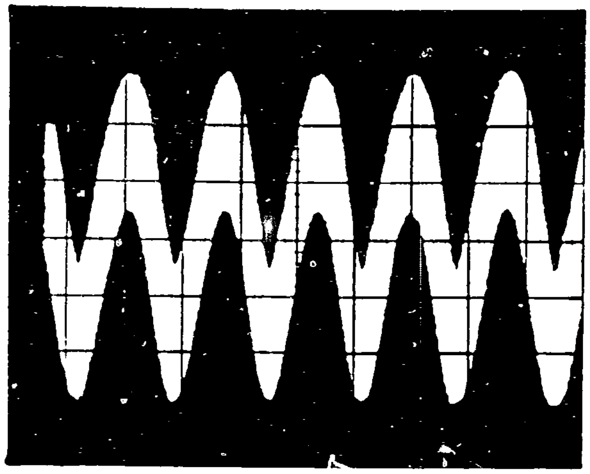
(b) First signal to positive terminal and second to negative is considered Polarity +.

(c) All measurements made with a Keithley 177 DVM on $20x10^3$ ohm scale.

After calibration, both the remote and local meters indicated a dose rate of 0.5 mR/hr at the ante-room location of the replacement detector and the signal from the detector was recorded (see page A-43). The 10V supply measured 9.99V, the 600V supply measured 605V, and the checksource coil measured 14 ma current, when tested. The signal output was ranging from 0 to 9.9V when measured with a DVM with background dose rate conditions and similarly varied when the checksource was activated, but at a much faster rate which appeared as approximately an averaged 5V level.

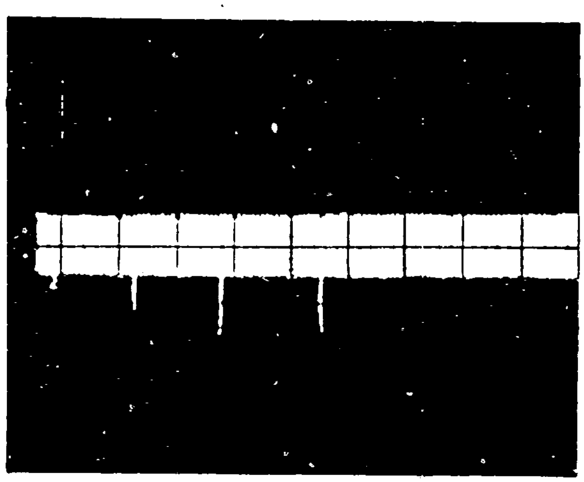
Time traces were taken of the output waveforms by photographing a storage oscilloscope trace. Figures 4-8 and 4-9 illustrate waveforms which exhibited the main differences between the original waveforms and the new ones (a complete set of plots are given on pages A-109 to A-115). Figure 4-8 shows the absence of the 120 Hz contamination on the 600V supply (which was also true for the checksource lines and the 10V supply). This improvement was probably the result of repairing the power supply capacitor in the readout module and is not indicative of the effect of replacing the detector. Figure 4-9 shows the pulsed voltage on the signal line, which has a significantly greater amplitude: 3.5V range previously and 9.9V with the new detector.

Both the high frequency and low frequency spectra taken on the signals show a continued low level contamination at both 16 and 20 kHz and harmonics; however, the magnitude is much lower than previously shown. The complete set of spectra are given in the Appendix on pages A-116 to A-121.



a) Vertical Scale
20 mV/Div

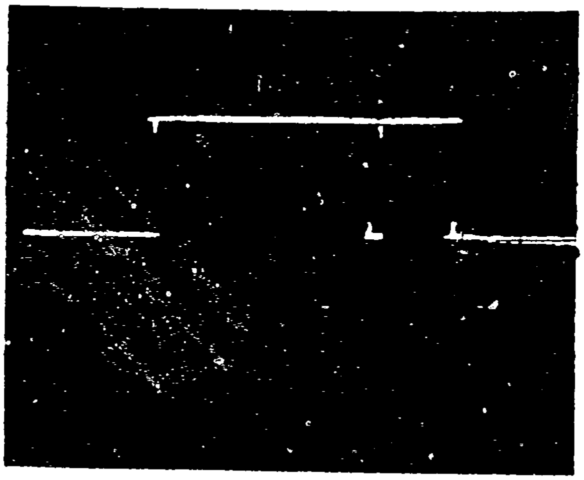
Horizontal Scale
10 mS/Div



b) Vertical Scale
100 mV/Div

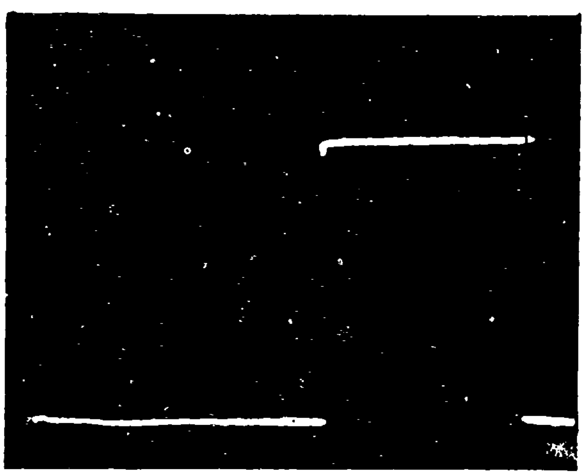
Horizontal Scale
0.2 Sec/Div

Figure 4.8 AC Fluctuations on 600V Supply After Replacement of Detector.



a) Vertical Scale
0.5 V/Div

Horizontal Scale
1 Sec/Div



b) Vertical Scale
0.2 V/Div

Horizontal Scale
0.5 Sec/Div

Figure 4.9 Fluctuation of SIGNAL OUT After Replacement of Detector.

## 4.5 MEASUREMENTS FOLLOWING ATTEMPTED DETECTOR REPLACEMENT IN CONTAINMENT

Following the testing of the detector installed in the ante-room, the containment monitor was to be replaced with the detector (serial # 111) which was just tested and calibrated. However, during the removal of the old detector, the connector to the detector was broken and insertion of the new detector was not possible. Dispute this problem, the old detector was removed for testing by Sandia Laboratory. Since there was no detector installed in the HP-R-211 circuit, the only measurements that would possibly provide any useful data were the TDR measurements on the cable. The results of these measurements are summarized in Table 4-5 and the strip chart traces are shown on pages A-123 to A-132.

Table 4-5

SUMMARY OF TDR INFLECTION POINTS FOR DAMAGED CABLE

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| Checksource | 168 | Increased R point | terminal block |
| | 247 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 379 | Large R increase | open circuit |
| +600V (RG59) | 179 | Increased R point | terminal block |
| | 179+ | Continuous R decrease | ? |
| | 274 | Increased R point | terminal block |
| | 374 | Slight continuous R decrease | ? |
| | 405 | Large R increase | open circuit |
| Signal (RG58) | 174 | Increased R point | terminal block |
| | 174+ | Continuous R decrease | ? |
| | 268 | Increased R point | terminal block |
| | 368 | Slight continuous R decrease | ? |
| | 395 | Large R increase | open circuit |

Table 4-5 (Continued)

| Signal | Distance (ft)* | Description** | Probable Cause |
|---|---|---|---|
| +10V | 163 | Increased R point | terminal block |
| | 245 | Increased R point | terminal block |
| | 342 | Slight continuous R decrease | ? |
| | 384 | Large R increase | open circuit |

*TDR to terminal block test cable(s) (15 ft) not included in distance.

**R is the abbreviation for resistance.

# 5. DATA ANALYSIS

Following the actual field data gathering and on-site preliminary interpretations (given in Section 4), detailed analysis of the data was performed off-site. This data analysis consisted both of reducing the recorded data and interpretation of measurements to infer physical characteristics of the instrumentation.

## 5.1 REDUCTION OF RECORDED DATA

As described in the previous section, a recording was made of the detector output signals for three conditions:

1. Original HP-R-211 response
2. HP-R-211 response after electronic calibration
3. Replacement detector following complete calibration.

Examination of the waveforms from the original detector showed that there was a +6V offset on the signal with pulses rising to 9.5V and falling back to 6V also present. The operations manual for the detector indicates that the proper range of signals is approximately 0-10V (with a 0.8V possible variation due to electronics). This correct span of operation observed on the output of the replacement detector indicated that some problem existed in the detector or in the containment penetration (cable passing into containment). However, it is extremely unlikely that a cable problem would produce a signal with an offset and pulses correspondingly clipped at the offset value. Hence, the detector was selected as the most likely candidate for having failed (i.e., not producing its normal output response).

A more quantitative analysis of the detector recordings was also attempted because, as noted during field measurements, the pulse rate (but not the pulse height) from the original detector appeared to be consistent with believed containment radiation levels. A summary of the count rate for the three measurements is given in Table 5-1. Note that the operation of the device requires that two ionizing events occur to produce the "up" and "down" transition of the output. This is due to the "flip-flop" logic in the detector circuitry. Because the output wave forms were observed to be of improper range for the original detector, a pulse shaping circuit was applied to the reproduced signal to generate a proper indication of the detector response. The diagram for this circuit is shown in Figure 5-1.

The first amplifier stage was applied to remove any signal offset (AC coupled) and to convert the detector output into overloaded pulse events (saturation of maximum amplifier output at approximately 11V). This produces a well-defined range of the signal between -11V and +11V for processing by the threshold detector. Any delay introduced by the amplifier is not important since ionization events in the detector would be random, and hence not effected by such delays. Following the amplifier, a threshold detector circuit was inserted and adjusted to trigger at approximately +5V with a hysteresis of 5V. This produced an output of +9.2V when the detector signal exceeded 5V and maintained this output until the signal dropped below 0V, which triggered an 0V output. The range of 0 to 9.2V was chosen because this was the minimum range normally resultant from the detector circuit. (However, a test to determine the effect of this range was also performed later.)

Table 5-1

COUNT RATES MEASURED FROM SIGNAL RECORDINGS

| Description of Data | Average* Count Rate (CPS) | Average** Reading in mR/hr | Ratio of CPS/(mR/hr) |
|---|---|---|---|
| Original Detector as found) | 301(3)[†] | 200(3) | 1.51 |
| Original Detector (after electrical calibration | 293(4) | 103(5) | 1.52 |
| Replacement Detector (background) | 0.23(.08) | 0.29(.09) | 0.79 |
| Replacement Detector (checksource) | 7.2(0.5) | 5.2(0.1) | 1.38 |

*Actual detector ionization event rate is twice the listed value.

**From a readout module connected to a pulse shaping circuit applied to the reproduced signal with a 9.2V range.

[†]Numbers in parentheses are the associated standard deviations.

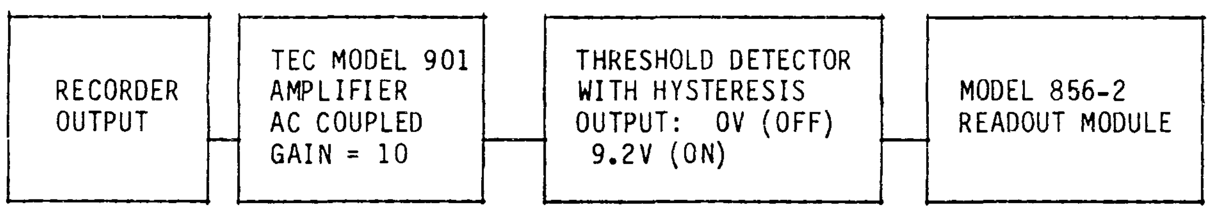



Figure 5-1. Diagram of Pulse Shaping Circuitry.

Referring to Table 5-1, the original detector count rates with the assumed pulse shaping are indicative of dose rates of approximately 200 mR/hr inside containment instead of 1.5 mR/hr as indicated on the control room readout. A review of the readout meter theory of operation shows why this extreme variation in indication occurs. The readout meter converts the detector signal transitions to logarithmic levels using a "log-pump" circuit. This circuit essentially consists of a series of capacitors (one for each decade range) which are charged by the maximum signal level and are then discharged through a resistor when the minimum signal level occurs. The resultant voltage output from the series of R-C circuits is summed to produce the readout value, with adjustments for "zero" and "span". Each R-C circuit (stage) is staggered by approximately a factor of ten in time response so that the more rapidly the input signal changes, the more stages reach near constant outputs and hence indicate higher radiation levels.

This entire circuit is dependent on the span of the input signal to generate the discharge levels from the capacitors through the resistors and is not sensitive to offset values due to the capacitive coupling. Since the range of the pulses was only 3.5 volts on the original detector, the readout module was not capable of interpreting the correct radiation levels. To understand the effect of various pulse ranges, a simple experiment was performed using a function generator, at various frequencies and output levels, acting as a "detector" input into a model 856-2 readout module. Figure 5-2 shows the results of this test. As expected from the log-pump circuit operating principles, at low signal ranges there is very little dependence of the meter on the input frequency (i.e., simulated

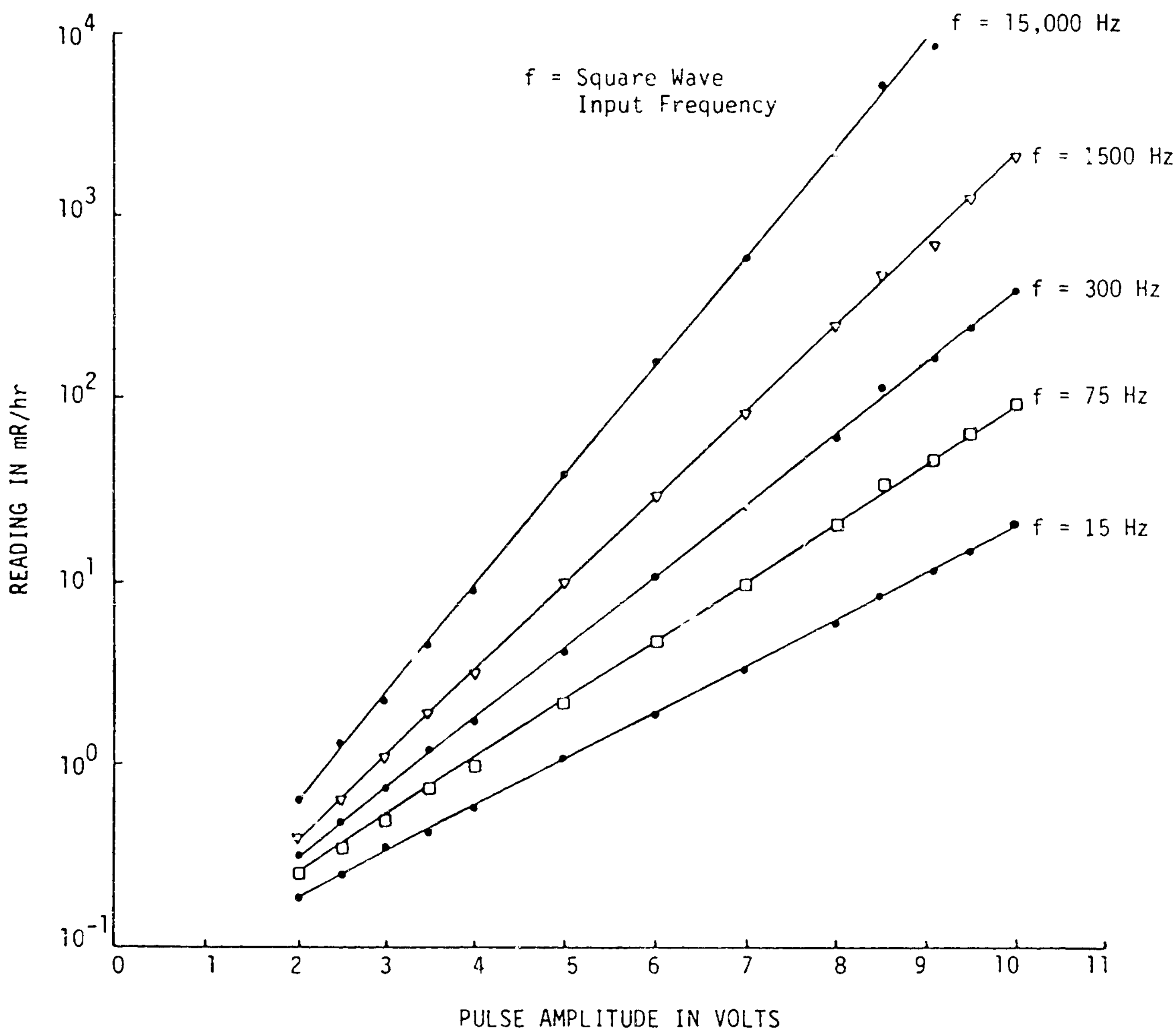



Figure 5-2 Victoreen Alarm/Rate Meter Response to Test Signals.

ionization events) due to the low charge/discharge levels in the circuit. This data sugggests that for the original detector with a 3.5V range, the response of the readout meter would not exceed 5 mR/hr event at full-scale radiation levels.

From Table 5-1 and Figure 5-2, there appears to be a near-constant conversion between pulse rate and readout indication at a fixed pulse voltage span with variations occurring at low radiation levels. This behavior is expected since the design of the system uses only the frequency of ionization events to generate an output (at a fixed pulse range). From the data gathered, this constant appears to be approximately 1.5 CPS/(mR/hr) which was also observed during mock-up testing (see page A-20). The variations in Table 5-1 for the replacement detector data are probably due to improper adjustments to the readout module, non-linearities at low readings, and difficulties in reading the meter at low values (needle variations). Note that the ratios of 1.55 and 1.51 are obtained for the replacement ratios in Table 5-1 if one standard deviation is added to the count rate and one standard deviation is subtracted from the dose rate. Thus the value of 1.5 CPS/(mR/hr) appears to be statistically acceptable as a count rate to dose rate conversion value.

For completeness in interpretation of this value, two other factors must be considered. Referring to Figure 5-2, a factor of 2 increase in response occurs if the output pulses of the detector change from 9.2V to 10V. Thus, if the meter were calibrated to expect pulses spanning 10 volts, the conversion value of 0.75 CPS/(mR/hr), or 1.33 (mR/hr)/CPS, is predicted.

The observations of a reading of 0.5 mR/hr background and of 9.9V pulse transitions during the measurements on the replacement detector suggest that this value is more nearly correct. With this conversion factor considered, the inferred dose rate indicated by HP-R-211 was 400 mR/hr inside containment. The second factor that needs to be emphasized is the fact that two ionization events must occur in the GM tube of the detector to achieve a complete pulse output. As mentioned previously, this is due to the "flip-flop" output conditioning of the detector in which each GM tube event triggers a change in state (i.e., ON to OFF or OFF to ON).

## 5.2 INTERPRETATION OF MEASUREMENTS

After acquiring the data and performing some analysis of the recorded data, HP-R-211 appeared to be non-functional (using the installed instrumentation) due to a reduced amplitude signal produced in the detector output circuitry. By comparing restored signal indications to expected dose rate levels, the remainder of the detector and the entire readout module appears to be operating correctly, at least within normal variations due to lack of recent calibration and some potential changes in the GM tube sensitivity.

As a result of these findings, an attempt to predict the problem in the detector was made based on comparisons of measurements obtained on the new detectors and on the HP-R-211 detector. Figure 2-4 shows the electrical circuit within the detector housing, and Tables 4-2 and 4-4 give the resistance measurements for the reference and original detectors, respectively. Note that the cable resistances are included in data from the original detector since it was installed inside containment; but any small resistances would not seriously change the results, and TDR measurements indicated no large cable resistances.

The only significant differences observed in the HP-R-211 data compared to the references were an increase in checksource resistance by 10 ohms, a low resistance path of only 305 ohms from signal in to +10V supply, and a small reduction in resistance between shield and +10V supply. The increase in the checksource resistance is within the expected variation in coil resistances and the added cable resistance and is not considered important. The extremely low resistance of 304 ohms between the signal line and the shield (ground) is probably responsible for the small reduction in the shield to +10V resistance, and therefore will not be considered separately unless analysis indicates otherwise.

Referring to the electrical circuit schematic in Figure 2-4, there are numerous paths between the signal line and the 10V supply, but only two main paths exist in the output section transistors Q6, Q7, and associated resistors. (The output section is considered the likely problem area due to indications of all other sections operating.) The first path consists of two fixed resistors R23 (10 k-ohm) and R21 (100 ohm), and the second path consists of Q6 (2N3906) and R20 (100 ohm). For the first path to produce a low resistance with a single failure, R23 would need to have a resistance of 200 ohms since R23 is normally much larger than the 304 ohms measured. However, the mechanism for such a reduction in resistance is not clear and, if R23 were reduced that low, normal operation of Q7 to pull the signal to ground would connect the +10V to ground through a 200 ohm resistance. If this occurred, the load on the 10V supply would have been 50 ma, which is much greater than the normal load, and would have produced variations in the 10V supply due to this excessive load. No extreme voltage variations were observed (see page A-84), which indicates this path was not responsible for the offset in the output.

The second path would require Q6 to have a 200 ohm short from emitter to collector (in the unpowered state) to produce the low resistance measurement. Since this path normally enables the HI output state (+10V) through a 100 ohm resistor, the loading on the signal line due to the readout module must be very low, and no variation on the 10V supply would be expected. Also, mechanisms for such a transistor failure are much more likely than for the resistor, R23, to have a reduction in resistance. This would also explain the reduction in the shield to 10V supply lines due to the formation of a 10.2 k-ohm path through resistor R22 if Q6 failed. As a result of this type of reasoning, along with analyses to determine alternate causes of the offset observed, it is felt that the cause of the offset present in the signal line is due to a low resistance path through Q6.

# 6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-211, the likely cause of the apparent failure of the monitor was a failure of transistor Q6 (see Figure 2.4). This resulted in a low resistance path between the 10V power supply and the signal, which held the Signal Out level within 3.5 volts of the power supply level, even when Q7 attempted to pull the level to ground.

Further analysis indicated that if the detector output signals were conditioned to their proper levels using external circuitry, a dose rate of approximately 400 mR/hr was indicated. Current results indicate that this circuitry would have been capable of restoring the proper signal if the Q6 failure progressed to fully open or shorted.

Other measurements indicated that with the exception of the failure of Q6 inside the detector housing, the HP-R-211 monitoring system was functioning properly.

## APPENDIX

## FIELD DATA SHEETS AND FIGURES

Included in this Appendix are the original field data sheets from the measurements which were left as originally filled out without corrections or alterations, except for some added comments. Also included is a complete set of photographs and strip chart results from the measurement program. Due to the separate measurements taken, this Appendix is divided into the following sections with starting page numbers given.

# SECTION A.1

## MOCK-UP MEASUREMENTS PRIOR TO FIELD TESTS

(with Figures)

REVIEW & PRE TEST COPY



| Technology for Energy Corporation | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 / REV. 0 |
|---|---|---|
| PROCEDURE | APPROVED M.V. Mathis, Director, Tech. Serv. Div. | DATE 8-11-80 |

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El-305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

| Active Signal Parameter | Time Domain Reflectometry | Impedance |
|---|---|---|
| Voltage | 225 mV nominal (into 50 ohm base) | $\leq$ 5V rms |
| Frequency | --- | 100Hz, 1kHz, 10kHz, 100kHz |
| Current | $\leq$ 10mA | $\leq$ 100mA |
| Other | 225mV, 110 picosecond pulses | --- |

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).

2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.

3. Burns & Roe Dwg. 3024, Sh. 30A.

4. Burns & Roe Dwg. 3043, Sh. 16D.

5. Burns & Roe Dwg. 3045, Sh. 34.

6. Burns & Roe Dwg. 3045, Sh. 34B.

7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.

8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.

9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).

10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.

11. Instruction Manual, Tektronix Model 335 Oscilloscope.

12. Instruction Manual, Lockheed Store-4 Recorder.

13. Instruction Manual, Tektronix SC502 Oscilloscope.

14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

| Signal | CABLE ~~Penetration~~ IT2931I | Cabinet 12 |
|---|---|---|
| +10V | | TB109-8 |
| 600V | | TB109-5 |
| SIG | | TB109-6 |
| GND | | TB109-10 |
| CS | | TB109-1 |
| CS | | TB109-2 |

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

Signature/Date

RHC 1/3 3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local & Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of ~~876~~5-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.

7 1/2 IPS DIRECT CHAN 1 DC COUPLED USING 465B AMP
GAIN = 50mV

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| Meter/Indicator/Switch | Local | Rmte |
|---|---|---|
| mR Mr/hr Meter Reading | ______ | ______ |
| Off-Operate-Alarm Function Switch | ______ | N/A |
| Fail Safe Indicator | On___ Off___ | N/A |
| High Alarm-Reset Indicator | On___ Off___ | N/A |

______________________
Signature/Date

4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fail-Safe Check Source push button during the measurement.

| TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|

10 MIN

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 10.084<br>50mV p-p ~~60~~/25K<br>20mV p-p 60 |
| b. | TB109-6<br>TB109-10 | (+)<br>(-) | (SIG IN) ______ ______<br>CS OUT CS IN |
| *c. | TB109-5<br>TB109-~~10~~ M | (+)<br>(-) | (600V) ________ |
| **d. | TB109-1 (open field side)<br>TB109-1 (cabinet side) | (+)<br>(-) | (≤500 mA est.) ______ |

*Use electrostatic voltmeter
**Link closed after measurement

Signature/Date

TEC TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO ____ | PHOTO ____ | PHOTO ____ |
|---|---|---|---|---|---|
| a. | TB109-1<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| b. | TB109-2<br>TB109-10 | CS | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| * c. | TB109-5<br>TB109-10 | +600V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| d. | TB109-6<br>TB19-10 | SIG | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| e. | TB109-8<br>TB109-10 | +10V | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |
| | | | PHOTO ____ | PHOTO ____ | PHOTO ____ |
| f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base ____<br>Vert Gain ____ | ____<br>____ | ____<br>____ |

45 MIN

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 1 |
| b. | TB109-6<br>TB109-10 | SIG IN<br>GND | |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | |

50MIN
TEKTRONIX 465B
~~0.5~~ 50MV

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., space, RF bandwidth, ~~video~~ RF bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|
| ~~[illegible]~~ PHOTO #1 | 25kHz & HARMONICS | | |

Signature/Date

TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

30 MIN

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| *a. | TB109-5<br>TB109-10 | +600V<br>GND | |
| b. | TB109-6<br>TB109-10 | SIG IN<br>GND | |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 2 |

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

| Procedure Step | Before | After | Remarks |
|---|---|---|---|
| | | | |
| See attached instrument shop procedure data sheet. | | | |

Instrument Shop Procedure No. ________

Signature/Date

9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

Signature/Date

10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| TERMINAL | SIGNAL IDENT. |
|---|---|
| TB109-1 (Blue) | C.S. |
| TB109-2 (Orange) | C.S. |
| TB109-3 (White) | Rem. Meter |
| TB109-4 (Yellow) IT2933C | HI N.C. |
| TB109-5 (RG 59/U, 72 OHM) | 600V |
| TB109-6 (RG 58/U, 50 OHM) | SIG IN |
| TB109-7 (RG 58/U, 50 OHM) | Shield |
| TB109-8 (Red) | +10V |
| TB109-9 (Green) IT2933C | Alert N.C. |
| TB109-10 (Blk)<br>(RG 59/U, 72 OHM) | GND<br>Shield |

Signature/Date

11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| TEST POINT | FROM | | TO | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue | IT1869I | Orange |
| b. | IT1869I | RG 59/U Center | IT1869I | RG 59/U Shield |
| c. | IT1869I | RG 58/U Center | IT1869I | RG 58/U Shield |
| d. | IT1869I | Red | IT1869I | Black |
| e. | IT1869I | Black | IT1869I | TB109-10 |

Record the data required below:

Coil! 30 ohm

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency → | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| a. cs | (INDUCTOR 4.51 mH) | (INDUCTOR 4.45 mH) | (INDUCTOR 6.86 mH) | 30.2 Ω | 41.4 Ω | 4.25 kΩ |
| b. Coax | 262 pF | 271 pF | 263 pF | 5.94 MΩ | 588 kΩ | 6.05 kΩ |
| c. | 4.2 nF | .62 nF | 361 pF | 2.86 kΩ | 2.86 kΩ | 2.35 kΩ |
| d. | 108 μF | 103 μF | INDUCTOR | 18.7 Ω | 11.1 Ω | 11.1 Ω |
| e. | INDUCTOR | INDUCTOR | INDUCTOR | 97.6 mΩ | 99.1 mΩ | 1.31 Ω |

Signature/Date

TEC TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

| Test Point | High R @ N ft. | Low R @ N ft. | Instrument Settings Ampl | Range | Mult | Photo No. * |
|---|---|---|---|---|---|---|
| a. | | | | | | |
| b. | | | | | | |
| c. | | | | | | |
| d. | | | | | | |
| e. | | | | | | |

45 MIN

*Utilize strip chart where available.

Signature/Date

13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NOTE: Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 / REV. 0 |
|---|---|---|---|

Polarity From = + To = −    Polarity From = − To = +

| TEST POINT | FROM LINK | TO LINK | RESISTANCE | R |
|---|---|---|---|---|
| CS a. | TB109-1 | TB109-2 | 30.4 Ω | 30.4 Ω |
| b. | | TB109-5 | | |
| c. | | TB109-6 | | |
| d. | | TB109-7 | | |
| e. | | TB109-8 | | |
| f. | | TB109-10 | | |
| g. | TB109-2 | TB109-5 | | |
| h. | | TB109-6 | | |
| i. | | TB109-7 | | |
| j. | | TB109-8 | | |
| k. | | TB109-10 | | |
| l. | TB109-5 | TB109-6 | >20 MΩ | >20 MΩ |
| m. | | TB109-7 | | |
| n. | | TB109-8 | | |
| 600v o. | | TB109-10 | >20 MΩ | >20 MΩ |
| SIG p. | TB109-6 | TB109-7 | 8.85 kΩ | 7.23 kΩ |
| q. | | TB109-8 | | |
| r. | | TB109-10 | | |
| s. | TB109-7 | TB109-8 | | |
| t. | | TB109-10 | .68 Ω | ~~.43~~ .56 Ω |
| 10v u. | TB109-8 | TB109-10 | 11.9[illegible] kΩ | 7.47 kΩ |

45 MIN

Close all links on TB109 (opened in Step 10) when finished with this step.

Signature/Date

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm ~~Unit~~ (Ante-room). RECORD S/N OF DETECTOR USED

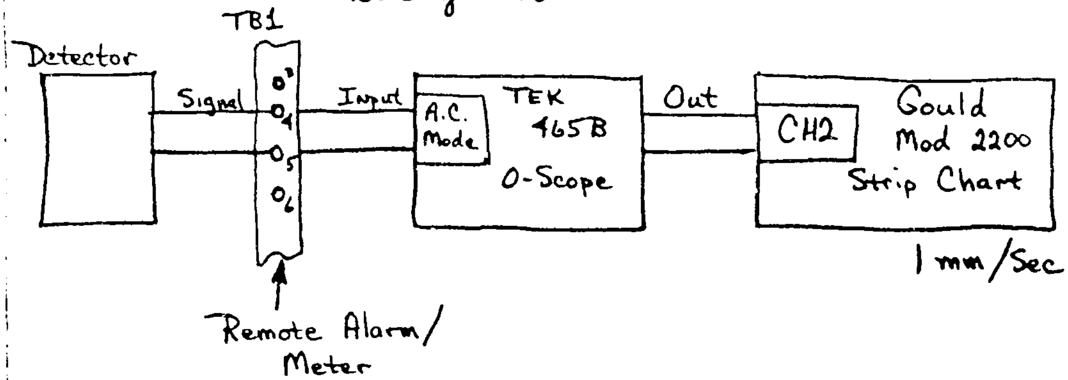
S/N

Signature/Date

TMI TESTS @ EG&G TRAILER

8/12/80 MV Mathis
JT Smith
JE Jones

① 17:04 Recording Pulses from Detector (10 MINUTE SPAN)
Background

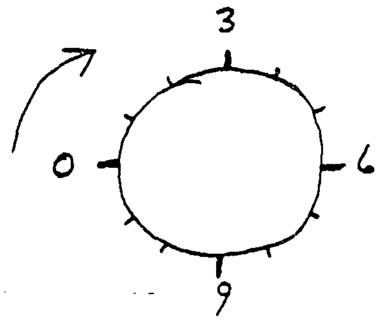



② 17:14 Recording Pulses with Check Source
Speed: 10 mm/Sec [See Figure Above]

– Performed ~~a~~ TDR measurements of 10' test cable mock-up (see analysis sheet). Using Gould 2200 strip chart recorder at 5 mm/sec speed, a length calibration factor was obtained. This ~~fact~~ measurement yielded 19 full divisions on the strip chart corresponding to 10 divisions on the TDR display. Thus ft/division will be divided by 1.9 when recorded on strip charts.

JE Jones

## CABLE DIELECTRIC SETTINGS




### 10' CALIBRATION VALUES (OPEN)

| CABLE PAIR | "OTHER" SETTING | |
|---|---|---|
| Red - Black (#22) | 4.25 | 4.50 Value Selected! |
| Blue - Orange | 4.75 | |

### MEASUREMENTS (10' LENGTH CABLE) [10' Test Cable & CLIPS USED]

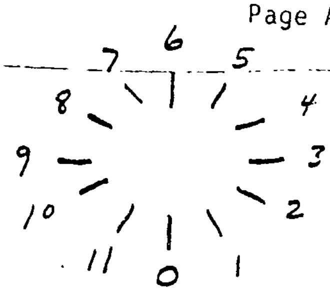
| CABLE PAIR | LENGTH (OPEN) | LENGTH (CLOSED) | DIELECTRIC |
|---|---|---|---|
| RED - BLACK (#22) | 10.25' | 10.1' | OTHER |
| RG58 | 10' | 10.1' | SOLID POLY |
| RG59 | 9.9' | 9.9' | SOLID POLY |
| BLUE - ORANGE | 9.9' | 10.0 | OTHER |
| BLACK - RG59 Shield | 9.85' | 10.05' | OTHER |
| BLUE - VIOLET | 9.9' | 10.0' | OTHER |

Due to above measurements, the "SOLID POLY" setting will be adequate for the RG58 & RG59 cables and the "OTHER" setting selected [at 4.5 relative value on potentiometer] for other cables.

8/12/80

J E Jones

VAR
POT




MOCK-UP DETECTOR CABLE

P calibrated for 10'

| Cable open | SET UP | | |
|---|---|---|---|
| Blue to org | OTHER | VAR | 6.25 |
| RG 59 | OTHER | VAR | 5.50 |
| RG 58 | OTHER | VAR | 5.50 |
| Red to Blk | OTHER | VAR | 6.00 |
| Blk to RG59 shield | OTHER | VAR | 5.00 |

CABLE TERMINATED INTO DETECTOR

| | out of scale | from strip chart |
|---|---|---|
| Blue to Org. | 10.3' | 10.6' |
| RG 59 | 10.2' | 10.4' |
| RG 58 | 10.2' | 10.4' |
| Red to B.Ck | 11.0' | 11.2' |
| Blk to RG59 Shield | 10.85' | 10.8' |

G.M. Mueller results

8/11/80

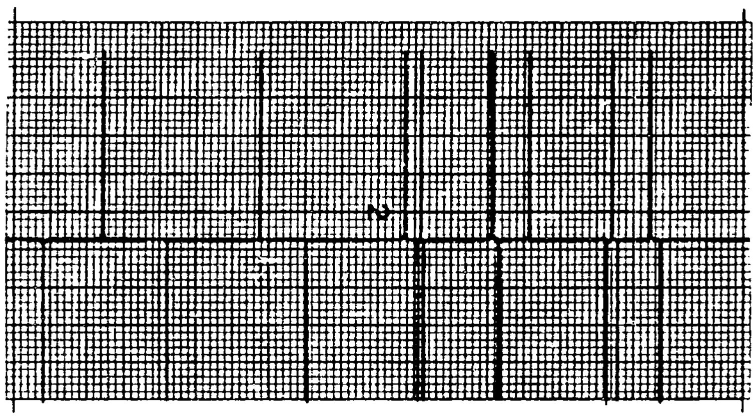
MOCK-UP TEST

Test in Trailer

(1) Background of Detector

Background Reading ∿ 0.2 mR/hr

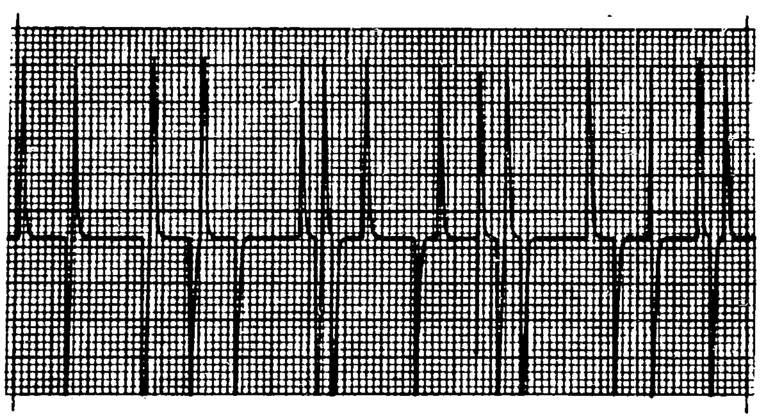
102 Counts/10 min.
Chart Speed: 1 mm/s



(Typical)

(2) Check Source in Detector

Check Source Reading ∿ 2 mR/hr
184 Counts/1 min.
Chart Speed 10mm/s

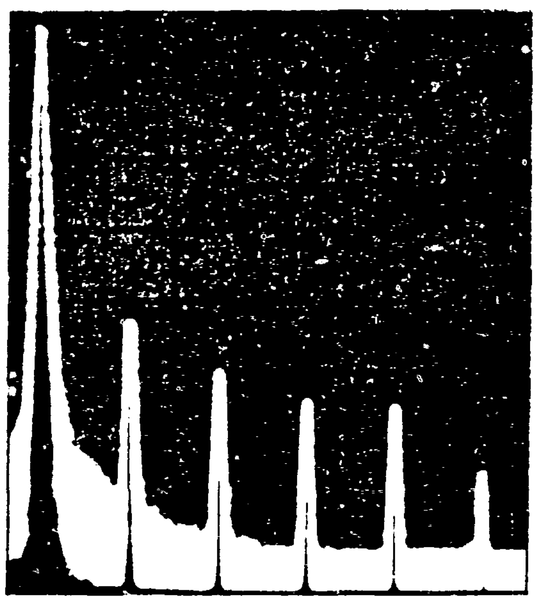


(Typical)

Mock-up Test (Trailer)

Low Frequency Spectrum

PHOTO #1



BW = 1KHz

Horiz. Scale: 20 KHz/Div
(0.1 s/Div Scan)

Vert. Scale: 10 dB/Div

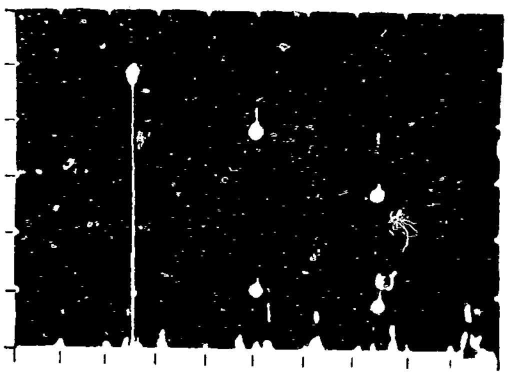
+10V Signal (AC Coupled)

Mock-up Test (Trailer)

Low Frequency Spectrum

0.0116 RMS

PHOTO #2



+10V Signal (AC Coupled)

Range: 0 - 100 KHz

20 KHz Harmonics Intensified

Vert. Scale: +10 dB Ref;
10 dB/Div

# SECTION A.2

## PRE-INSERTION DETECTOR PIN MEASUREMENTS

(Procedure pages used to record data)

| TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|
| | | REV. 0 |

SERIAL #1405

Pre-Insertion Pin Measurements

| TEST POINT | FROM | | TO | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT1869I | Blue | IT1869I | Orange |
| b. | IT1869I | RG 59/U Center | IT1869I | RG 59/U Shield |
| c. | IT1869I | RG 58/U Center | IT1869I | RG 58/U Shield |
| d. | IT1869I | Red | IT1869I | Black |
| e. | IT1869I | Black | IT1869I | TB109-10 |

Record the data required below:

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency → | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| a. | | | | | | |
| b. | -16 → +60 pF | 24 pF | 18.6 pF | O.F. | 6.6 MΩ | 720 kΩ |
| c. | 3.9 nF | 0.30 nF | 47 pF | 2.93 kΩ | 2.93 kΩ | 2.85 kΩ |
| d. | 108 μF | 103 μF | O.F. | 18.5 Ω | 10.9 Ω | 10.7 Ω |
| e. | | | | | | |

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Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

SERIAL #1405

(TEC #8032) Kiethly 177 DMM : 200 kΩ SCALE

PRE-INSERTION PIN MEASUREMENTS

| TEST POINT | + FROM LINK | — TO LINK | RESISTANCE Polarity + | − | |
|---|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | 30Ω | 30Ω | |
| b. | | TB109-5 | ~ | ~ | |
| c. | | TB109-6 | ~ | ~ | |
| d. | | TB109-7 | ~ | ~ | |
| e. | | TB109-8 | ~ | ~ | |
| f. | | TB109-10 | ~ | ~ | |
| g. | TB109-2 | TB109-5 | ~ | ~ | |
| h. | | TB109-6 | ~ | ~ | |
| i. | | TB109-7 | ~ | ~ | |
| j. | | TB109-8 | ~ | ~ | |
| k. | | TB109-10 | ~ | ~ | |
| l. | TB109-5 (E) | TB109-6 | ~ | ~ | |
| m. | | TB109-7 | ~ | ~ | |
| n. | | TB109-8 | ~ | ~ | |
| o. | | TB109-10 | ~ | ~ | |
| p. | TB109-6 (G) | TB109-7 | 9.7kΩ | 9.7kΩ | 8.79 7.16 |
| q. | | TB109-8 | 9.7kΩ | 9.63kΩ | 8.78 6.84 |
| r. | | TB109-10 | 9.7kΩ | 9.7kΩ | |
| s. | TB109-7 | TB109-8 | 17.7kΩ | 17.7kΩ | 7.57 11.84 |
| t. | | TB109-10 | 0 | 0 | |
| u. | TB109-8 | TB109-10 | 17.7kΩ | 17.7kΩ | |

20K scale MBM 8-14-80

~ = OPEN

Note: TB109-7, TB109-10 are identical at detector

Close all links on TB109 (opened in Step 10) when finished with this step.

CASE : SHORTED To GROUND

J E Jones 8/14/80
Signature/Date

~~14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).~~

Signature/Date

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

SERIAL #111

PRE-INSERTION PIN MEASUREMENTS

(TEC #8032) Kiethly 177 DMM : 20 kΩ SCALE

| TEST POINT | FROM LINK | TO LINK | RESISTANCE Polarity + | − |
|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | | |
| b. | | TB109-5 | | |
| c. | | TB109-6 | | |
| d. | | TB109-7 | | |
| e. | | TB109-8 | | |
| f. | | TB109-10 | | |
| g. | TB109-2 | TB109-5 | | |
| h. | | TB109-6 | | |
| i. | | TB109-7 | | |
| j. | | TB109-8 | | |
| k. | | TB109-10 | | |
| l. | TB109-5 | TB109-6 | | |
| m. | | TB109-7 | | |
| n. | | TB109-8 | | |
| o. | | TB109-10 | | |
| p. | TB109-6 | TB109-7 | 8.77kΩ | 7.34kΩ |
| q. | | TB109-8 | 8.27kΩ | 6.56kΩ |
| r. | | TB109-10 | 8.77kΩ | 7.34kΩ |
| s. | TB109-7 | TB109-8 | 7.44kΩ | 11.77kΩ |
| t. | | TB109-10 | 0 | 0 |
| u. | TB109-8 | TB109-10 | 11.77kΩ | 7.44kΩ |

Note: TB109-7 / TB109-10 are identical at detector

Close all links on TB109 (opened in Step 10) when finished with this step.

Jeff Mueller 8/15/80
Signature/Date
JEJ

14. ~~PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm Unit (Ante-room).~~

Signature/Date

# SECTION A.3

## PROCEDURES FOR PRE-REMOVAL AND POST-REMOVAL MEASUREMENTS

| Technology for Energy Corporation | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 / REV. 0 |
|---|---|---|
| PROCEDURE | APPROVED M.V. Mathis, Director, Tech. Serv. Div. | DATE 8-11-80 |

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for removal and replacement of Area Radiation Monitor HP-RT-0211 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE:

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-RT-0211 is part of a redundant ARM system at elevation 305'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-RT-0211 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests. Since the UUT is to be replaced by a calibrated spare, personnel safety should be enhanced by the ability to more ~~reliability~~ reliably monitor the radiation levels at El-305'.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be pervormed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1869I (terminations shall be removed and replaced on TB109 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

| Active Signal Parameter | Time Domain Reflectometry | Impedance |
|---|---|---|
| Voltage | 225 mV nominal (into 50 ohm base) | ≤ 5V rms |
| Frequency | --- | 100Hz, 1kHz, 10kHz, 100kHz |
| Current | ≤ 10mA | ≤ 100mA |
| Other | 225mV, 110 picosecond pulses | --- |

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations. Furthermore, the replacement detector will be connected to TB-109 (Cabinet 12) through an interface cable and calibrated by Instrumentation personnel using applicable procedures for Calibration of the Victoreen Area Radiation Monitor (field calibration source corrected for half-life decay). Baseline passive measurements will be repeated on the replacement unit.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

| | | | |
|---|---|---|---|
| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

<u>References</u>:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-211 & HP-R-212 (Sheet 5 of 11).

2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.

3. Burns & Roe Dwg. 3024, Sh. 30A.

4. Burns & Roe Dwg. 3043, Sh. 16D.

5. Burns & Roe Dwg. 3045, Sh. 34.

6. Burns & Roe Dwg. 3045, Sh. 34B.

7. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.

8. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.

9. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).

10. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.

11. Instruction Manual, Tektronix Model 335 Oscilloscope.

12. Instruction Manual, Lockheed Store-4 Recorder.

13. Instruction Manual, Tektronix SC502 Oscilloscope.

14. Composite Electrical Connection Diagram, HP-R-211 (Sketch dtd 8/8/80).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-RT-0211 as follows:

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| Signal | Cable ~~Penetration~~ IT2931I | Cabinet 12 |
|---|---|---|
| +10V | | TB109-8 |
| 600V | | TB109-5 |
| SIG | | TB109-6 |
| GND | | TB109-10 |
| CS | | TB109-1 |
| CS | | TB109-2 |

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. PRE-REMOVAL, POST-REMOVAL: Notify Shift Supervisor/Shift Forman of start of test on HP-RT-0211.

2. PRE-REMOVAL, POST-REMOVAL: Verify power is applied to HP-RT-0211.

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Signature/Date JEJ

3. PRE-REMOVAL, POST-REMOVAL: record present signals and readings and indications on 856-2 Readout Module (Local &5Remote). Record Signal-in at TB109-6 ("T"), and record output from TB1 of 8~~2~~6-2 Readout A9 for a unit for one hour on FM Tape Recorder. Remove recorder when finished.
7½ IPS DIRECT (CHAN 1)
DC COUPLED THRU 465B AMPLIFIER — No! +8V offset required AC coupling.
G=50mV & CALIBRATED

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

| Meter/Indicator/Switch | Local | Rmte |
|---|---|---|
| ~~Mr~~ mR/hr Meter Reading | 1.5 mR | 3.5 mR |
| Off-Operate-Alarm Function Switch | OPERATE | N/A |
| Fail Safe Indicator | On ✓ Off ___ | N/A |
| High Alarm-Reset Indicator | On ___ Off ✓ | N/A |

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4. PRE-REMOVAL, POST-REMOVAL: Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = $\pm$ 1%) measure the DC voltage or current at the following test points.

NOTE: For signal d. it will be necessary to depress Fall-Safe Check Source push button during the measurement.

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 9.4V |
| b. | TB109-6<br>TB109-~~10~~ 7 | (+)<br>(-) | (SIG IN) 7.5V CS OUT 7.5V CS IN |
| *c. | TB109-5<br>TB109-~~10~~ 10 | (+)<br>(-) | (600V) 605V |
| **d. | TB109-1 (open field side)<br>TB109-1 (cabinet side) | (+)<br>(-) | (≤500 mA est.) -13 mA<br>NOTE: LAST CALIBRATION 2/78. |

*Use electrostatic voltmeter
**Link closed after measurement

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TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

NO. TP-101

REV. 0

5. PRE-REMOVAL, POST-REMOVAL: Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO 3 | PHOTO 4 | PHOTO 5 |
|---|---|---|---|---|---|
| ✓a. | TB109-1<br>TB109-10 | CS | Time Base 5mSec<br>Vert Gain 2mV | 2 mSec<br>1V | 1 mSec<br>1V |
| | | | PHOTO 6 | PHOTO 7 | PHOTO 8 |
| ✓b. | TB109-2<br>TB109-10 | CS | Time Base 5mSec<br>Vert Gain 2V | 2mSec<br>1V | 1mSec<br>1V |
| | | | PHOTO 9 | PHOTO 10 | PHOTO 11 |
| ✓*c. | TB109-5<br>TB109-10 | +600V | Time Base 5mSec<br>Vert Gain .2V | 2mSec<br>.2V | 10mSec<br>.2V |
| | | | PHOTO 12 | PHOTO 13 | PHOTO 14 |
| ✓d. | TB109-6<br>TB19-~~10~~ 7 | SIG | Time Base 1mSec<br>Vert Gain 1V | 2mSec<br>1V | 2mSec<br>2V |
| | | | PHOTO 15 | PHOTO 16 | PHOTO 17 |
| ✓e. | TB109-8<br>TB109-10 | +10V | Time Base 2mSec<br>Vert Gain 2V | 5mSec<br>1V | 2mSec<br>.5V |
| | | | PHOTO 18 | PHOTO 19 | PHOTO 20 |
| *f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base 10mSec<br>Vert Gain 2mV | 20mSec<br>1mV | .2mSec<br>1mV |

Note: Fuse on 110V Blown... Repeat Tests

21 Time: 10μSec Gain: 10mV
22 Time: 50μSec Gain: 10mV
23 Time: 2mSec Gain: 5mV

*Use X10 probe

Sync the oscilloscope and photograph the waveform using three time base and vertical gain settings. Mark the back of the photographs with the instrument tag number and parameter measured.

Signature/Date 8/13/80

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 REV. 0 |
|---|---|---|---|

6. PRE-REMOVAL, POST-REMOVAL: Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 24, 25 |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 26 |
| *c. | TB109-5<br>TB109-10 | +600V<br>GND | 27 |

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope presentation adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., ~~[illegible]~~ RF bandwidth, RF ~~video~~ bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

| SPECTRUM IDENT | FREQUENCY | AMPLITUDE | REMARKS |
|---|---|---|---|
| #24 | 0 - 1.4 MHz | ~ | Low Range Noise |
| #25 | 0 - 3.5 MHz | ~ | Low Range Noise |
| #26 | 0 - 3.5 MHz | ~ | Low Range Noise |
| #27 | 0 - 3.5 MHz | ~ | Very Low Noise |

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Signature/Date

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

7. PRE-REMOVAL, POST-REMOVAL: Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # | REMARKS |
|---|---|---|---|---|
| *a. | TB109-5<br>TB109-10 | +600V<br>GND | 28 | 20 kHz & Harmonics Peaks |
| b. | TB109-6<br>TB109-~~10~~7 | SIG IN<br>GND | 29 | Dominantly 1/f Noise ~32 kHz Harmonics |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 30, 31 | Peaks at 16 kHz & 20 kHz Harmonic<br>120 Hz Harmonics |

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max)

If PSD plots from any one of the three signals show high and unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

J. E. Jones 8/13/80
Signature/Date

8. PRE-REMOVAL ONLY: Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

see copy of shop procedure following

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| Procedure Step | Before | After | Remarks |
|---|---|---|---|
| ____ | ____ | ____ | LAST CALIBRATION 2/78 |
| See Attachment Pages 1A & 1B | | | |
| Major Change: +22V unregulated P.S. was @ +13.7V. Capacitor replaced ⇒ 20.2V & +10V adjusted downward since it comes from +22V line. | | | |
| See attached instrument shop procedure data sheet. | | | |

Instrument Shop Procedure No. ________

8/13/80
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9. PRE-REMOVAL, POST-REMOVAL: Remove all power from HP-RT-0211 (Tag Open TB501 links 25, 26, and 27 per procedure AP 1002).

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10. PRE-REMOVAL, POST-REMOVAL: Open links for all field wires from Cable IT1869I at TB109 (Cabinet 12).

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

| TERMINAL | SIGNAL IDENT. |
|---|---|
| TB109-1 (Blue) | C.S. |
| TB109-2 (Orange) | C.S. |
| TB109-3 (White) | Rem. Meter |
| TB109-4 (Yellow) IT2933C | HI N.C. |
| TB109-5 (RG 59/U, 72 OHM) | 600V |
| TB109-6 (RG 58/U, 50 OHM) | SIG IN |
| TB109-7 (RG 58/U, 50 OHM) | Shield (Signal) |
| TB109-8 (Red) | +10V |
| TB109-9 (Green) IT2933C | Alert N.C. |
| TB109-10 (Blk)<br>(RG 59/U, 72 OHM) | GND<br>Shield |

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JEJ

11. PRE-REMOVAL, POST-REMOVAL: Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|---|
| | | | REV. 0 |

| TEST POINT | FROM * (Red Lead) | | TO * (Black Lead) | |
|---|---|---|---|---|
| | CABLE | WIRE COLOR/TYPE | CABLE | WIRE COLOR/TYPE |
| a. | IT18691 | Blue (TB109-1) | IT18691 | Orange (TB109-2) |
| b. | IT18691 | RG 59/U Center (-5) | IT18691 | RG 59/U Shield (-10) |
| c. | IT18691 | RG 58/U Center (-6) | IT18691 | RG 58/U Shield (-7) |
| d. | IT18691 | Red (-8) | IT18691 | Black (-10) |
| e. | IT18691 | Black (-10) | IT18691 | TB109-10 |
| f. | IT18691 | RG 58/U Shield | IT18691 | RG 58/U Center |

* Values in parenthesis refer to normal TB connection points
Record the data required below

| Test Point | Capacitance | | | Impedance | | |
|---|---|---|---|---|---|---|
| Frequency | 100 Hz | 1 kHz | 100 kHz | 100 Hz | 1 kHz | 100 kHz |
| (COIL) a. | O.F. | -5.77 µF | -3.26 nF | 40.4 Ω | 49.1 Ω | 436 Ω |
| b. | -50 nF | 5 nF | 10 nF | O.F.* | O.F.* | 54 Ω |
| c. | O.F. | 90 nF | 12 nF | U.F. | 570 Ω | 116 Ω |
| d. | O.F. | 20 µF | -40 nF | U.F. | 25 Ω | 48.7 Ω |
| e. | -6 → 9 mF | -382 µF | -56 nF | 400-1400 mΩ | 924 mΩ | 28.6 Ω |
| f. | ERR4 | ERR4 | 12 nF | ERR4 | ERR4 | 116 Ω |

reverse polarity

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O.F. = overflow ; U.F. = underflow
* intermittant kΩ reading?
ERR4 = open or shorted; DC bias won't work

12. PRE-REMOVAL, POST-REMOVAL: Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

| Test Point | High R @ N ft. | Low R @ N ft. | Instrument Settings Ampl | Range | Mult | ~~Photo~~ Strip Chart No. * |
|---|---|---|---|---|---|---|
| a. | | | 500 | 100'/Div | 1 | 12a-1, -2 |
| b. | | | | | | 12b-1, -2 |
| c. | | | | | | 12c-1, -2 |
| d. | | | | | | 12d-1, -2 |
| e. | | | | | | 12e-1, -2 |

*Utilize strip chart where available.

Repeat c. With Terminal Block + 10' COAX → f. 12f-1, -2

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13. PRE-REMOVAL, POST-REMOVAL: Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

NO!
~~NOTE:~~ Open links for IT2933C from TB109 terminals 11, 12, 13, and 14. The appropriate wires should be marked accordingly.

TEC

TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

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| TEST POINT | FROM LINK | TO LINK | RESISTANCE (POLARITY From = + To = −) | RESISTANCE (POLARITY From = − To = +) |
|---|---|---|---|---|
| a. | TB109-1 | TB109-2 | 40.2 Ω | 40.2 Ω |
| b. | | TB109-5 | >20 megΩ | >20 megΩ |
| c. | | TB109-6 | >20 megΩ | >20 megΩ |
| d. | | TB109-7 | >20 megΩ | >20 megΩ |
| e. | | TB109-8 | >20 megΩ | >20 megΩ |
| f. | | TB109-10 | >20 megΩ | >20 megΩ |
| g. | TB109-2 | TB109-5 | >20 megΩ | >20 megΩ |
| h. | | TB109-6 | >20 megΩ | >20 megΩ |
| i. | | TB109-7 | >20 megΩ | >20 megΩ |
| j. | | TB109-8 | >20 megΩ | >20 megΩ |
| k. | | TB109-10 | >20 megΩ | >20 megΩ |
| l. | TB109-5 | TB109-6 | >20 megΩ | >20 megΩ |
| m. | | TB109-7 | >20 megΩ | >20 megΩ |
| n. | | TB109-8 | >20 megΩ | >20 megΩ |
| o. | | TB109-10 | >20 MΩ | >20 megΩ |
| Scale = 20K p. | TB109-6 | TB109-7 | 8.62 kΩ | 6.53 kΩ |
| 2K q. | | TB109-8 | 305 Ω | 305 Ω |
| 20K r. | | TB109-10 | 10.0 kΩ | 10.0 kΩ |
| 20K s. | TB109-7 | TB109-8 | 6.97 kΩ | 8.59 kΩ |
| 2K 100 200Ω t. | | TB109-10 | 1.96 Ω | 1.96 Ω |
| 20K u. | TB109-8 | TB109-10 | 8 k kΩ | 6.97 Ω |

Close all links on TB109 (opened in Step 10) when finished with this step.

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† links closed on TB109 1 through 9

14. PRE-REMOVAL ONLY: Utilizing all interface cable connect the replacement Victoreen Model 887-2 Detector to the appropriate terminals of TB1 of the Remote Meter/Alarm ~~####~~ (Ante-room). RECORD S/N OF DETECTOR USED.

★ replaced detector

~~[illegible]~~ 111
S/N

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| TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 |
|---|---|---|
| | | REV. 0 |

15. PRE-REMOVAL ONLY: Apply power to HP-RT-0211. After a minimum of 30 minutes warm up time perform ~~electronic~~ calibrations in accordance with applicable instrument shop procedures. Record the before and after readings for each step where adjustments are required and list below:

| PROCEDURE STEP | BEFORE | AFTER | REMARKS |
|---|---|---|---|
| | | | |

ELECTRONIC CALIBRATION NOT NEEDED -- PERFORMED IN STEP 8 & NO CHANGES HAVE OCCURRED.

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16. PRE-REMOVAL ONLY: Utilizing the Victoreen field calibration source perform calibration with source decay corrections in accordance with applicable Instrument Shop Procedures.

See copy of shop procedure following.

Instrument Shop Procedure No.

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|---|---|---|---|

17. Repeat Step 3. PRE-REMOVAL ONLY

| | LOCAL | RMTE |
|---|---|---|
| ~~MR~~ mR/Hr Meter Reading | .5 mR/hr | .5 mR/hr |
| Off-Operate-Alarm Function Switch | OP | N/A |
| Fail Safe Indicator | On ✓ Off ___ | N/A |
| High Alarm-Reset Indicator | On ___ Off ✓ | N/A |

~~& RECORD~~ (SEE STEP 3, p. 4)

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15 MINUTES BACKGROUND, THEN REFER TO LOG BOOK

18. ~~Repeat Step 4. PRE-REMOVAL ONLY~~

| SIGNAL | CABINET 12 | TEST LEAD | READING |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | (+)<br>(-) | (10V) 9.99V |
| b. | TB109-6<br>TB109-~~10~~ 7 | (+)<br>(-) | (SIG IN) 0-9.88V (CS OUT) 5.0V (CS IN) |
| *c. | TB109-5<br>TB109-~~10~~ 10 | (+)<br>(-) | (600V) 605 |
| **d. | TB109-1 (Open-Field Side)<br>TB109-1 (Cabinet Side) | (+)<br>(-) | ($\leq$500 ~~MA~~ mA est.) -14.1 |

*Use electrostatic voltmeter
**Link closed after measurement

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TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

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19. Repeat Step 5. PRE-REMOVAL ONLY

| SIGNAL | CABINET 12 | PARAMETER | PHOTO ~~32~~ 35 | PHOTO 36 | PHOTO 37 |
|---|---|---|---|---|---|
| ✓ a. | TB109-1<br>TB109-10 | CS | Time Base 5 mSec<br>Vert Gain .2V | 2 mSec<br>50 mV | 50 µSec<br>50 mV |
| | | | PHOTO 38 | PHOTO 39 | PHOTO 40 |
| ✓ b. | TB109-2<br>TB109-10 | CS | Time Base 10 mSec<br>Vert Gain 50 mV | 2 mSec<br>50 mV | 50 µSec<br>20 mV |
| | | | PHOTO 41 | PHOTO 42 | PHOTO 43 |
| ✓ *c. | TB109-5<br>TB109-10 | +600V | Time Base 10 mSec<br>Vert Gain 20 mV | .2 Sec<br>100 mV | 20 mSec<br>100 mV |
| | | | PHOTO 32 | PHOTO 33 | PHOTO 34 |
| ✓ d. | TB109-6<br>TB19-~~10~~ 7 | SIG | Time Base 1 Sec<br>Vert Gain .5V | .2 Sec<br>.5V | .5 Sec<br>.2V |
| | | | PHOTO 44 | PHOTO 45 | PHOTO 46 |
| ✓ e. | TB109-8<br>TB109-10 | +10V | Time Base .1 mSec<br>Vert Gain 20 mV | 5 mSec<br>50 mV | .2 mSec<br>20 mV |
| | | | PHOTO 47 | PHOTO 48 | PHOTO 49 |
| ✓ f. | TB109-10<br>TB501-27 | GND<br>ACGND | Time Base .2 mSec<br>Vert Gain 5 mV | .2 mSec<br>2 mV | 50 µSec<br>2 mV |

* Use x10 Probe

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20. Repeat Step 6. PRE-REMOVAL ONLY

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| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| a. | TB109-8<br>TB109-10 | +10V<br>GND | 50 |
| b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 51 |
| * c. | TB109-5<br>TB109-10 | +600V<br>GND | 52 |

* CAUTION: DECOUPLE.

SPECTRUM IDENT FREQUENCY AMPLITUDE REMARKS

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TEC | TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101 | REV. 0

21. Repeat Step 7. PRE-REMOVAL ONLY

| SIGNAL | CABINET 12 | PARAMETER | PHOTO # |
|---|---|---|---|
| ✓* a. | TB109-5<br>TB109-10 | +600V<br>GND | 53 |
| ✓ b. | TB109-6<br>TB109-~~10~~ 7 | SIG IN<br>GND | 54 |
| c. | TB109-8<br>TB109-10 | +10V<br>GND | 55 |

*DECOUPLE

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22. Repeat Step 9. PRE-REMOVAL ONLY

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23. PRE-REMOVAL ONLY: Remove interface cable connected in Step 14 and re-connect apprpriate field terminals to TB1 of the Remote Meter/Alarm Unit (Ante-room).

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24. PRE-REMOVAL ONLY: Reapply power by closing links opened in Step 22. Verify unit is operating as before by comparing meter readings with those taken in Step ~~8~~ 9.

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TITLE IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL)

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25. Repeat Step 3 at least 1 hour prior to entry for removal of HP-RT-0211. RECORDER MUST BE STARTED NO EARLIER THAN 1 HOUR BEFORE ENTRY...POWER LINKS SHOULD BE OPENED FOR REPLACEMENT OF DETECTOR THEN CLOSED.

ALL SUBSEQUENT STEPS ARE FOR POST REMOVAL MEASUREMENTS.

26. POST-REMOVAL ONLY. Repeat Step 3. (p 23)

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27. POST-REMOVAL ONLY. Repeat Step 4. (p 24)

Signature/Date

28. POST-REMOVAL ONLY. Repeat Step 5. (p 26)

Signature/Date

29. POST-REMOVAL ONLY. Repeat Step 6. (p 27)

Signature/Date

30. POST-REMOVAL ONLY. Repeat Step 7. (p 28)

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31. POST-REMOVAL ONLY. Repeat Step 9. (p 29) (Do Not Do Step 8).

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32. POST-REMOVAL ONLY. Repeat Step 10. (p 29)

Signature/Date

33. POST-REMOVAL ONLY. Repeat Step 11. (p. 30)

Signature/Date

34. POST-REMOVAL ONLY. Repeat Step 12. (p. 32)

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35. POST-REMOVAL ONLY. Repeat Step 13. (p. 32)

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36. POST-REMOVAL ONLY. Apply power to HP-RT-0211 and verify proper operation utilizing applicable instrument shop procedures.

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| TEC | TITLE | IN-SITU: MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-RT-0211 (MOCK-UP) (PRE-REMOVAL) (POST-REMOVAL) | NO. TP-101<br>REV. 0 |
|---|---|---|---|

I hereby certify that this Test Procedure has been completed as written and that all data has been correctly entered and filed as requested.

TEC Representative ____________________
Signature/Date

Instrumentation ____________________
Signature/Date