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GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION — RICHLAND, WASHINGTON

DOCUMENT NO.
HW-64154

COPY NO.

DATE
March 8, 1960

ISSUING FILE

TITLE

100-N DECONTAMINATION FACILITY DESIGN GUIDE.

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ROUTE TO	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE

Facsimile Price $ 1.60
Microfilm Price $ .80

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100-N DECONTAMINATION FACILITY DESIGN GUIDE

MASTER

BY

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MARCH 8, 1960

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100-N DECONTAMINATION FACILITY DESIGN GUIDE

INTRODUCTION

Space has been reserved near the southeast corner of the 100-N Area for the 122-N Decontamination Facility. Previous correspondence * between Burns and Roe, Inc. and General Electric has discussed various facilities which might be needed in this building.

The concepts of the decontamination processes are under active development by research groups at Hanford. At present, there are several workable processes known; each one has one or more fairly serious drawbacks. (4)

It is believed, however, that the general outline of the processes are similar enough that a chemical handling facility may now be designed which will be capable of applying whatever process is ultimately chosen to decontaminate the NPR primary loop. This document presents the concepts and data to make design of the facility possible.

KINDS OF DECONTAMINATIONS

Several kinds of decontaminations will be required at various times for various reasons at the 100-N site. These are:

1. Minor personnel decontaminations, laboratory spills, etc. These are generally of a minor and near-routine nature. Standard operating procedures are well established at Hanford for this sort of thing and they will not be considered as a portion of the 122-N facility.
2. Decontamination of external surfaces of piping and equipment, walls, floors, walkways, etc. These are also of a semi-routine nature and will be taken care of by standard operating procedures and/or special procedures developed as required. The only effect this type of decontamination may have on 122-N is that a small amount of storage space may be required for special chemicals and equipment.
3. Small parts decontamination. Two facilities are being provided in the 105-N Building for the purpose of decontaminating tools, valves, dummy fuel elements, tube caps, etc. These facilities will not affect the 122-N facility except for requiring a small storage space for chemicals.
4. Single pass reactor decontamination. This type of decontamination will require facilities at 122-N. These are discussed later.

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* See References 1 through 8.

5. Single cell primary loop decontamination. This type of decontamination will require facilities at 122-N. These are discussed later.

6. Major primary loop decontamination. This type of decontamination will utilize the same facilities as single cell decontamination except that considerably more time and expense will be involved. The fact that this requirement exists causes an increase in the storage space at 122-N.

122-N FACILITY DESIGN PHILOSOPHY

Because of the expense and time involved in cleaning a portion or all of the primary loop, decontamination will be done only when the need becomes relatively great. For planning purposes the following rough estimates of frequency may be used:

1. Single pass decontamination - once every three months.
2. Single cell decontamination - one cell every six months.
3. Entire primary loop - once every five years.

It should be noted that these estimates are little more than guesses, based on test loop operating experience. Difficulties with fuel element integrity and/or maintenance problems with primary loop equipment will have serious effects on these frequencies.

It is not necessary to obtain more accurate estimates for our present purposes; however, the fact that the decontamination facilities will be used probably only one or two days every few months gives the key to the design philosophy. Low capital cost should be paramount over operating cost. Manual controls should be used rather than automatic in most cases. Spare equipment will not be required except where safety might be involved. Equipment may be utilized for multiple functions, even when some time is required to switch functions (for example, dry chemical feeders may be used to feed more than one chemical).

It must be realized that the decontamination procedures to be applied have not been chosen. These are under active development and it is entirely possible that the processes may undergo considerable change even years after reactor startup. It is, therefore, important that the 122-N facility be as flexible as possible and that it be capable of considerable future revision and modification without excess cost.

SINGLE PASS REACTOR DECONTAMINATION

During normal reactor operation, a high temperature corrosion film will be deposited on the walls of the system. This film will contain radioactive corrosion products in sufficient quantity to cause significant radiation levels (on the order of 10 to 100 mr/hr) near the primary piping.

The only parts of the primary system which will require frequent and regular access are the front and rear faces of the reactor (during charge-discharge operations) and, to a lesser extent the major equipment in the evaporator cells. Present indications are that methods which allow decontamination of the interior of the front and rear connectors can be developed to be practical.

The decontamination process is visualized to take place essentially as described below.

The reactor will be shut down, the primary coolant will be cooled to about 200°F and pressure will be reduced to less than 200 psig. Primary coolant flow will be reduced to approximately 20 gpm per tube.

When these conditions are reached and the 122-N facility is readied, all reactor process tubes associated with one (or two) rear riser(s) will be placed on diversion with the diversion effluent being routed to the chemical waste storage tank. Concentrated decontaminant chemical, delivered from 122-N, will be injected into the top of the corresponding inlet riser(s). The concentrated chemical, diluted by the normal primary water flow, will pass through the inlet riser, the associated inlet connectors, process tubes, and outlet connectors and leave through the diversion system. The loss from the primary recirculating system must be continuously made up by low pressure injection pumps.

After the required contact period for adequate decontamination (possibly 5 to 15 minutes) the concentrated chemical injection will be stopped. The tubes will be left on diversion for a few minutes to allow flushing.

The entire process will be repeated, either one or two risers at a time, until all connectors have been cleaned.

The equipment for and operation of this system is described in greater detail in Reference (9).

The 122-N facility will be required to accomplish delivery of up to 450 gpm of concentrated decontaminant to the 105-N Building via an underground six inch carbon steel line. It would be very desirable to heat this stream to as near 200°F as possible before it leaves 122-N. (This will be especially true if the chemical is stored as a dry powder and must be dissolved to make a concentrated solution). A proposed method of accomplishing this is presented later.

SINGLE CELL PRIMARY LOOP DECONTAMINATION

The carbon steel portions of the primary loop can be decontaminated effectively in a single, relatively simple step. The stainless steel portions, however, require more complicated procedures for effective decontamination. The only promising procedures developed to date for stainless steel require two or more chemical steps with rather precisely controlled concentrations, temperatures, velocities and times of contact. Several intermediate and final flushes are also required. At this time, the only decontamination procedures practical for stainless steel necessitate recirculation of the chemical steps as opposed to the single pass procedure for carbon steel.

Descriptions of some of the proposed methods of primary loop decontamination are given in Reference (4).

The 122-N facility must be capable of preparing quite concentrated chemical solutions and injecting them into the primary system. Because of the high concentrations required and the high cost of the special chemicals, the chemicals should be added in dry form directly to the water in the primary loop by means of facilities similar to those described below.

DESCRIPTION OF 122-N FACILITIES

The facilities described herein are not necessarily those which are recommended. They are described here as possible ways of solving the problem and as an aid in visualizing what is required. The actual design of the facilities will be accomplished by Burns and Roe.

Chemical Storage Facilities

At the present time, it appears probable that the chemicals which will be used to decontaminate the NPR will be available in dry form. It also appears probable that the choice of chemicals may change from time to time. It is proposed, therefore, that the 122-N Storage facilities be provided in the form of warehouses for the storage of relatively small containers of dry chemicals. (Most of the proprietary compounds under current investigation are not available in bulk. The most desirable containers would probably be 55 gallon steel drums).

In order to store sufficient chemicals to decontaminate the entire primary loop, the following assumptions are made:

1. The system volume is 180,000 gallons.
2. The first chemical step requires 2 lbs/gal. concentration.
3. The second chemical step requires 0.75 lbs/gal. concentration.

In order to store sufficient chemicals to provide one complete single pass decontamination, the following assumptions are made:

1. The cooling water flow will be 20 gpm per tube for the 1000 tubes.
2. The desired concentration of chemical is 10 percent by weight.
3. A flow of 15 minutes is required.

On the bases of the above assumptions, storage space must be provided for 360,000 lbs. of Chemical #1, 135,000 lbs. of Chemical #2, and 250,000 lbs. of Chemical #3. Approximate densities of some chemicals which might be used are:

#1 - 140 lbs per cubic foot
#2 - 170 lbs per cubic foot
#3 - 120 lbs per cubic foot

The warehouse facilities for these chemicals should be minimal consistent with adequate weather protection. Heating will not be required but adequate ventilation must be provided to prevent excessive summer temperatures with consequent chemical deterioration. Sufficient aisle space must be provided for rapid access to the chemicals since they will be consumed at very high rates.

Adequate space should be allowed near the warehouse for installation of storage tanks should future development show the need for liquid chemicals. It would also be possible to modify portions of the warehouse(s) later to accommodate bulk dry chemicals if desired.

Adequate handling facilities must also be provided for transfer of the chemicals from railroad cars to storage.

Chemical Transfer Facilities

Decontamination of major portions of the primary system will be infrequent. When it is done, however, large amounts of chemicals must be transferred in a short time. In the case of single pass decontamination, for example, based on the assumptions previously given, Chemical #3 will be used at a peak rate of greater than 1.1 tons per minute. (The necessity of flushing after decontamination will reduce this to an average rate of about 0.7 tons per minute, however). Provisions must be made for transferring the chemicals from storage to the point of mixing.

Although the chemicals to be handled will most probably be of low toxicity and relatively safe to handle, the transfer method chosen must be designed to minimize dusting.

Single Pass Decontaminant Mixing Facilities

This facility must be capable of delivering up to 450 gpm of concentrated chemical on demand to the 105-N Building. The exact concentration will, of course, depend upon the chemical finally chosen. It is assumed for the present (along with the assumptions listed previously) that the chemical used will permit at least a 40 percent by weight solution to be made.

The rate of delivery of the concentrated chemical must be controllable from the 105-N Building (presumably simply by use of a throttling valve) while the concentration must remain fairly constant. It would be desirable to drop the chemical concentration sharply to zero without stopping flow. The system described below would accomplish these.

Filtered water (probably deoxygenated) at a flow of up to 450 gpm would be supplied to the mixing facility at a temperature of 180 to 200°F. Heating would be by direct steam injection or by steam heated heaters, automatically controlled to provide uniform temperature (±10°F) regardless of flow.

This stream would flow into an agitated mixing tank and would be controlled by the liquid level in the tank. The dry chemical would be added to the tank in proportion to the flow into the tank. Baffling would be provided to assure a low amount of undissolved chemical in the effluent from the tank. (A small amount of carryover would be permissible since it would have time to dissolve in the pipeline to the 105-N Building).

The concentrated chemical would be pumped to the 105-N Building via a six inch insulated pipeline. The pressure required would be relatively high (200 to 250 psig) since it is to be injected directly into the primary system and since the pipelines are relatively small with consequent high pressure drop.

The operation of this facility would be visualized as follows:

1. When the reactor is almost prepared for single pass decontamination, the hot water will be started through the mix tank and sent through the 122 to 105 pipeline to waste in order to warm the line and its insulation. This will prevent crystalization of the concentrated chemical during the first few minutes of operation.

2. As the tubes to be cleaned in the first cycle are being diverted, the hot water flow to 105-N will be stopped and sufficient dry chemical will be added to the mix tank to bring its contents to the desired strength.

3. As injection of the chemical into the top of the selected risers takes place, the mix tank level controller, the temperature controller, and the dry chemical feeders will maintain the temperature and concentration of the chemical being supplied to 105-N.

4. After the proper time has elapsed (assumed here to be 15 minutes) the dry chemical feeders will be stopped. (It may also be desirable to bypass the mix tank with the hot water supply). The flow of hot water will then be reduced slowly to prevent abrupt flow changes in the reactor process tubes during the flushing period.

5. The entire procedure will be repeated for each cycle until all connectors have been cleaned.

It should be noted that several other items, not properly part of the 122-N facility, must be provided for successful single pass decontamination. For example, a makeup flow of approximately 2700 gpm of 100°F demineralized water must be injected into the primary loop at shutdown pressure while the tubes being decontaminated are diverted. It is probable that the fill pumps and/or injection pumps will be capable of providing this. In addition to the makeup, complete waste disposal facilities will be required for the spent decontaminant. For a description of the waste disposal facilities, see Reference (10).

Although the chemical to be used must have a relatively low corrosion rate on carbon steel, the mix tank, pump, and transfer line will be exposed to higher concentrations and longer times than will the process tube connectors. It is therefore recommended that the transfer pump be rubber lined or stainless steel, that the mix tank be lined or painted with appropriate material, and that the pipeline to 105-N be schedule 80 or 160 carbon steel. Careful operating procedures must be set up to assure complete flushing of the system after use.

Major Primary Loop Decontaminant Mixing Facilities

Decontamination of the entire primary loop will be done utilizing the 122-N facilities provided for single cell decontamination. The existance of the requirement of cleaning the entire primary loop should influence decisions of size and capacity of single cell decontaminant mixing equipment toward the high side.

Single Cell Decontaminant Mixing Facilities

The primary loop piping is arranged so that any of the five evaporator-pump cells may be isolated from the remainder of the primary loop. The fluid in an isolated loop may be circulated through a decontaminant heater and the cell piping by using the primary pump.

It would be possible to drain the cell piping and refill with the decontaminant. This drain and fill technique, however, could not be used when decontaminating the entire loop since reactor cooling must not be interrupted. It will therefore be necessary to provide a facility to inject the decontaminant chemical into the primary loop while it is full and circulating.

All of the satisfactory two-step decontamination processes developed so far for stainless steel utilize at least one step with the chemical concentration near two pounds per gallon. The maximum solubility of these chemicals is on the order of four pounds per gallon. It is therefore impractical to attempt reaching the desired concentration in the full circulating loop by injecting a concentrated solution; too much chemical would be wasted in the bleed. It is also impractical to add the dry chemical directly into the primary loop because of transport problems with the dry chemicals. The system described below for the decontamination of a single cell avoids these problems.

The equipment required would be an insulated pipeline from the cells in the 190-N Building to 122-N, a heated, agitated mix tank with dry chemical feeders, a return pump and an insulated return pipeline. Materials of construction similar to those of the single pass decontaminant mixing facility would be suitable.

The operation would be as follows:

1. The reactor will be shut down and the cell to be decontaminated will be valved off from the rest of the system. (Note: there is no technical reason why the reactor could not be started up again at a reduced power on the remaining four cells).
2. The separated cell is brought to a nominal pressure of 50 to 100 psig, a temperature of approximately 200°F, and an average flow velocity of about five feet per second.
3. While steps one and two are being accomplished, the 122-N facility, including the insulated lines to and from 190-N, are filled with filtered water and recirculated until the temperature is brought to about 200°F.
4. The lines between 122-N and 190-N are valved into the separated cell piping in such a manner that a portion of the circulating cell flow is bypassed to and through the mix tank in 122-N, returning to the cell via the pump and insulated return line.
5. Dry chemicals are added directly into the mix tank at as high a rate as possible until the proper concentration is reached.
6. Circulation within the cell piping is continued for the specified time. Meanwhile, the mix tank, pump, and interbuilding piping is drained (to the chemical waste storage tank) and flushed.
7. When this step is completed, the primary pump will be stopped and the spent decontaminant will be drained to the chemical waste storage tank (or will be purged there with incoming flush water) and the cell piping will be flushed, either on single pass or by filling, circulating, and draining, until sufficient flushing is obtained.
8. The entire process will be repeated for the other chemical step(s) required to complete the decontamination. One major difference is that there is strong indication at present that oxygen should be kept out of the system from the start of the acidic step on. This would mean that the chemical must be mixed with deoxygenated water, any draining of the system must be done with the use of an inert gas, and that all flush waters must be deoxygenated.

Note that this will provide circulation of the decontaminant through the 122-N facility while it is in use. Contamination will therefore be carried into the facility. After completion of the entire decontamination process, the 122-N facility should be relatively clean since it will also receive the full decontamination process. During operation, however, fairly high activities will be present in the circulating fluids; the actual operation of the facility should be done remotely and/or automatically.

LAYOUT OF FACILITY

The chemical feeders, mix tanks, heaters, pumps, piping, and controls should be enclosed in a light building at the north end of the 122-N facility. The chemical storage warehouse(s) should be located nearby to the south.

The chemical mix building should have minimum heating to prevent damage to the facility in below zero weather. Provisions must be made for adequate ventilation to permit its use in summer. The chemical mix tanks should be enclosed and vented to the outside, perhaps with an exhaust fan, to prevent high concentrations of water vapor and chemical fumes within the building. The tanks, pumps, and piping must be insulated to permit near-boiling temperatures. The equipment for single cell decontamination should be arranged compactly and located some distance from other equipment to permit erection of lead brick or concrete block shielding walls if such should prove desirable.

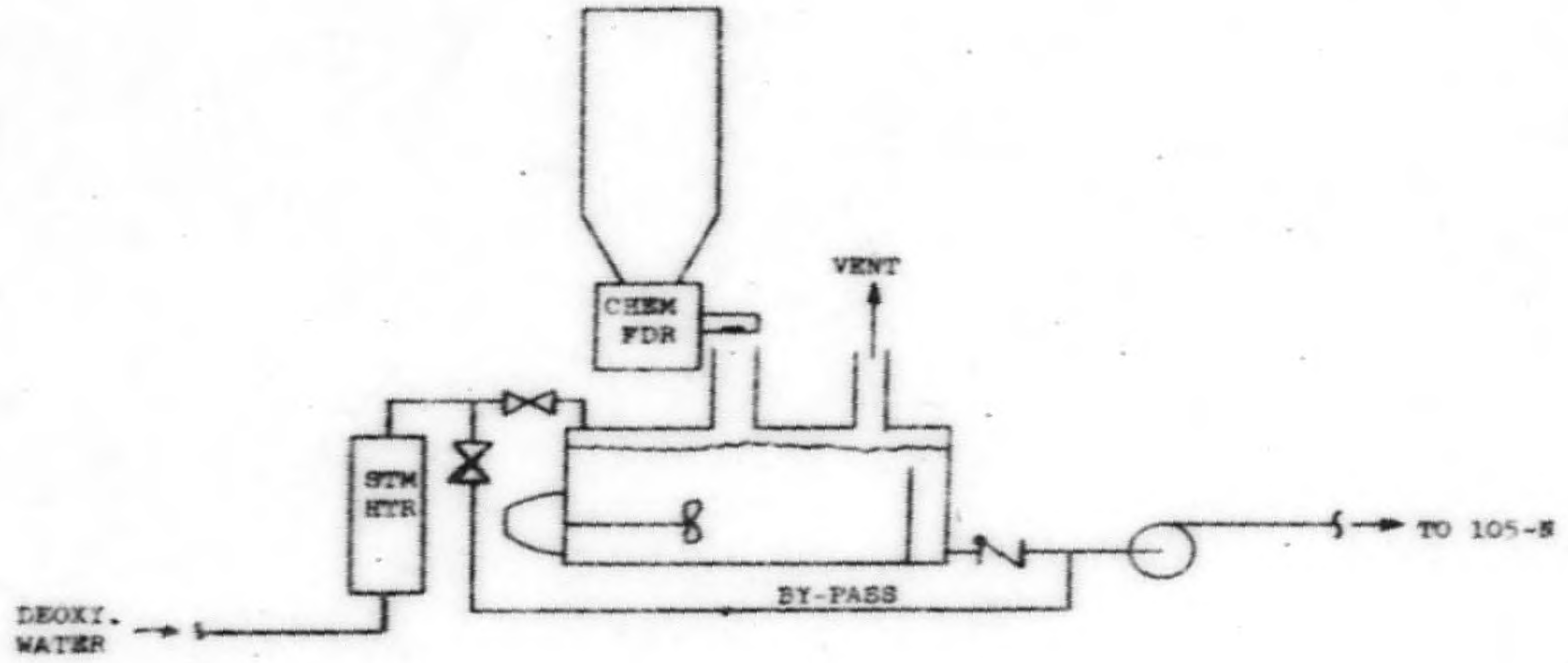
Provisions should not be made to mix decontaminants for both single pass and single cell at the same time. Such equipment as dry chemical feeders and steam heaters should lend themselves to dual function, in fact, it may be feasible to provide only one mixing facility.

WDBainard

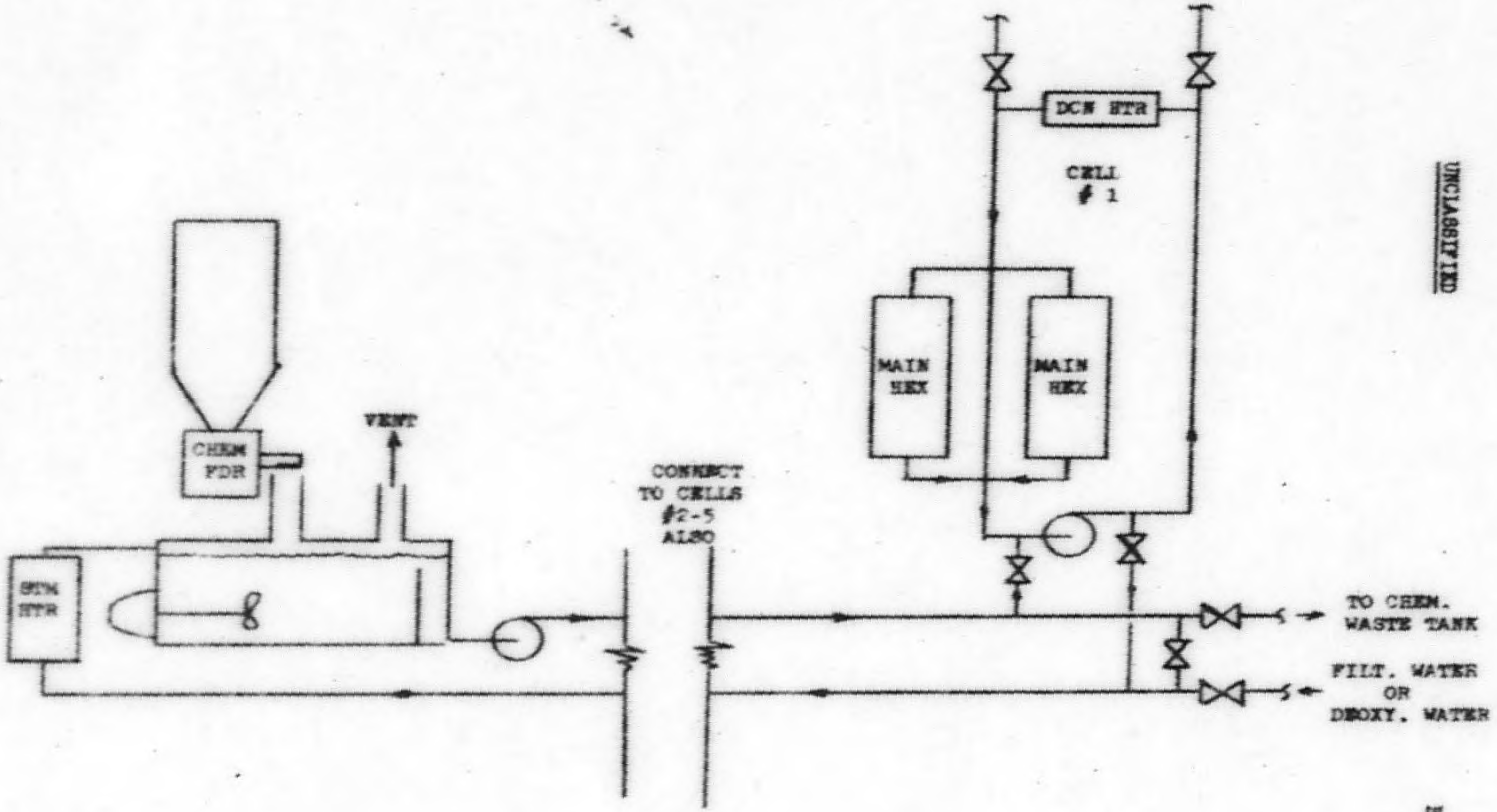
W. D. Beinard
System Design
NPR PROJECT SECTION

WD Beinard:esb

Attachments



SCHEMATIC PIPING DIAGRAM
PROPOSED SINGLE PASS DECONTAMINANT
MIXING FACILITY



SCHEMATIC PIPING DIAGRAM
PROPOSED SINGLE CELL DECONTAMINANT
MIXING FACILITY

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