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MODIFICATION OF FUEL ELEMENT TEST
FACILITIES - 1706-KER PROJECT CGI-839

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DESIGN CRITERIA
MODIFICATION OF FUEL ELEMENT TEST
FACILITIES - 1706-KER - PROJECT CGI-839

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DESIGN CRITERIA
MODIFICATION OF FUEL ELEMENT
TEST FACILITIES - 1706-KER
PROJECT CGI-839

1.0 INTRODUCTION

The following criteria outlines the basis, objectives, and fundamental methods that shall govern the preparation of final design for "Project CGI-839, Modification to Fuel Element Test Facilities - 1706 KER". These modifications will provide the equipment to test NPR size fuel elements in the KER recirculating loops.

The preparation of this design criteria and associated scope and detail design drawings has been authorized under Directive No. HW-485.

2.0 OBJECTIVE

The objective of this criteria is to define the functional and operational requirements of the facilities to be modified and to outline the general descriptions of the proposed equipment.

3.0 CRITERIA

3.01 Design Philosophy

All loop equipment and piping will be designed for operation consistent with standards of pile and loop operation, control and safety set forth in the current editions of Process Standards, Reactor, "Hanford Works Standards and Design Guides" and ASME Pressure Vessel Code, Sections I to IX and the ASA Code for Pressure Piping, ASA B 31.1. The noise level in structures modified under this program shall be suppressed to the practical minimum. The design of internal piping, interior finish, and equipment foundation shall be upon this basis.

3.02 General Requirements and Considerations

The 1706-KER Recirculation Test Facility of KE Reactor is operated to obtain experimental data regarding high temperature reactor coolant technology and high temperature fuel element testing.

The facility consists of four in-pile recirculating loops. These loops will permit testing of fuel elements with the existing process tubes of 2.1 inches I.D. To provide adequate in-reactor fuel element test facilities to support the development of NPR fuel, two KER loops, #3 and #4 will be converted to provide a process tube of 2.7 inches ID that will be operated at typical NPR irradiation conditions. The remaining loops No. 1 and 2, will be modified to provide additional flow and heat transfer capacity for greater flexibility in the testing of high temperature fuel elements smaller than the NPR size. New pumps, heat exchangers, and minor piping modifications will be required in all loops.

In conjunction with the loop modifications, improvements will be made to several supporting facilities. These are (1) Process heat exchanger

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raw water back-up pumps, (2) Loop No. 2 demineralized water pump and supply piping, (3) Remote monitoring of process pump instrumentation, (4) emergency process back-up water piping improvements, (5) coincidence rupture detection instrumentation, (6) improved water sampling facilities and (7) new Hot Maintenance and Decontamination Room Building addition.

3.03 Recirculating Loops Operating Conditions - General

Loops No. 3 and 4

The maximum loop operating pressure was determined as the allowable high temperature pressure limit established by the creep-rupture life and yield strength properties of an in-pile NPR zirconium process tube.

In accordance with Process Standards, the maximum loop coolant temperature was set at 25°C below the saturation temperature of the maximum allowable tube pressure. This limit will insure suppression of coolant boiling. The maximum tube powers to be permitted in the loops have been estimated from the maximum flows that are proposed as obtainable from the available 105-KE process water back-up system pressures when operating the loops on single-pass flows where tube outlet temperatures are not to exceed 195°F. This operating limit will permit start-up of the KE reactor when the KER loop is on single pass without a prior discharge of KER tube test fuel elements. The tube power is based on a calculated emergency flow of 100,000 lbs/hr at a tube Δt of 135°F. This flow will be produced by the estimated BORP after installation of 105-KE zirconium tubes, I&E Fuel and Project CG-775.

Operating design point flows were chosen to give equivalent NPR fuel temperatures or near equivalent NPR specific tube powers. Process tube pressure losses are equivalent to the values calculated for NPR fuel at a K reactor charge length.

The following operating conditions have been developed from the above criteria:

Operating Limits

Maximum tube exit pressure - 1850 psig

Maximum tube exit coolant temperature - 575°F

Maximum tube power - 3,800 KW

Tube flow - 80,000 lbs/hr. (approximately 200 gpm at inlet water temp)

Test section pressure drop - 160 psig

Loops No. 1 and 2

To extend the flexibility of the existing facility in support of proposed fuel element research and development, the flow capacities of KER loops No. 1 and No. 2 will be increased. The existing process tubes and nozzle equipment will not be modified. New recirculating pumps and primary heat exchangers will be required for the following scope operating conditions:

Operating Limits⁻⁷⁻
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Maximum tube power - 2,200 KW

Tube flow - 40,000 lbs/hr (approximately 100 gpm at inlet water temp)

Test section pressure drop - 75 psig

Maximum tube outlet pressure and temperature limits will remain the same as specified in the Process Standards.

3.04 Mechanical Criteria3.04.1 Modifications to Loops #3 and #4

Process Tube Assembly - A new process tube and nozzle assembly will be provided for loops #3 and #4. The process tubes will be specially selected NPR zircaloy-2 size tubes that have been cut to the KE reactor process tube length.

The tube to be tied into loop #3 will be installed in the KE front-to-rear test hole which occupies the reactor lattice space 3855. The test hole in process channel 3674 will be used for the loop #4 zirconium tube. The responsibility for the use of the vacated tube channels 3565 (existing loop #3) and 4268 (loop #4) shall remain with the Research and Engineering Section.

Process Tube - The tube shall be of material constituents and quality as outlined in the NPR specifications HWS-6502, "Specifications for Zircaloy-2 Process Tubes for 105-N", Project CAI-816.

During loop operation, the process tube metal temperature shall not be permitted to exceed 700°F during service to limit gaseous contamination and subsequent embrittlement.

Process tube creep deformation shall not exceed 1% in 5 years. Alternating and steady state elastic stress shall not exceed the fatigue limits set forth in BUSHIPS SSN/S51 (551B) Ser SSB-596 "Tentative Structural Design Basis for Reactor Pressure Vessels and Directly Associated Components".

Process Tube flexural stresses shall not exceed the stress range determined by equation (14), paragraph 622 of the American Standard Code for Pressure Piping, ASA B31.1. Allowable hot and cold stresses for equation (14) shall not exceed those determined by the provisions of paragraph UA-601a, Appendix Q, Section VIII of the ASME Boiler and Pressure Vessel Code.

The process tube shall be supported by the gunbarrel in the B shield. In the graphite channel, the tube shall be unsupported in the channel and will be allowed to deflect approximately 0.25 inches at the center of the tube span, at which point the tube will be resting at the bottom of the channel.

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The installation of full channel cross section supporting members such as trunnion or saddle blocks is not feasible without enlarging the hole through the biological and thermal shields.

Nozzle, Gunbarrel and Connector Assembly

The nozzle, gun barrel, and connector assembly shall be of an arrangement similar to the existing KER nozzle assemblies.

The nozzle assembly shall consist of an end cap, shielding plug, and nozzle barrel and a flange to process tube seal. The inlet and outlet assemblies shall be of similar design. The gunbarrel assembly shall provide bending moment support for the process tube at the reactor face and graphite channel. The existing test hole "B" shield shielding rings shall be used with the new gunbarrel. A reactor atmosphere gas seal shall be provided between the gunbarrel and B shield centering flange and between the gunbarrel and nozzle assembly.

The gunbarrel shall permit unrestricted thermal expansion of the process tube. Gunbarrel keyway stops will maintain the process tube assembly within the approximate center of the reactor block.

A dual connector assembly shall be used to carry the loop process water to the loop supply and discharge riser piping. The connectors shall be made from 1 1/4" O.D. tubing of .12 inch wall.

Flared fittings shall be used to connect the connector assemblies to the nozzle assembly.

The nozzle, gunbarrel, and connector tubing shall be made of a 300 series type stainless steel in accordance with material specifications ASTM-A213, "Specification for Seamless Alloy Steel Boiler, Superheater, and Heat Exchanger Tubes" and ASTM A-167 "Corrosion - Resisting Chromium - Nickel Steel Plate, Sheet, and Strip."

The ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels shall be used as a basis for the design of the wall thickness and reinforcement for the nozzle and flange assembly.

The exceptions in the design to the national power piping and vessel codes are the flared fittings used on the connector and nozzle joint and the seal between the process tube and nozzle. These exceptions are being followed due to the limited space available within the tube lattice which prohibits the use of an approved flange joint. A welded connection cannot be used within the process tube pattern. Experience from in-reactor operation and out-of-pile rupture testing with similar joints in high temperature and pressure service has shown that these joints have been consistently stronger than the tubing used in

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the joint. A preliminary requirement to the acceptance of the final detail nozzle assembly design will be the demonstrated pressure testing of the assembly at conditions prescribed by the ASME Code Section VIII, rupture and operational pressure tests; paragraph UG-101.

Recirculating Process Pumps - New Process pumps and motors will replace the existing loop recirculating pumps. The new pump operating requirements are estimated to be:

1660 ft. TDH at 200 gpm and 437°F water

There will be two pumps in parallel in each loop. Each pump shall be capable of developing the above flow and head independently of the other pump. If one pump fails, the other pump will be operated to provide full total flow at approximately the same total discharge pressure. Loop flows will be controlled by a throttling valve in the common discharge header.

Water temperatures will vary from startup at 70°F to as high as 500°F during normal operation.

The pump shall be capable of continuous operation with suction water temperatures at 600°F. Maximum system design pressure, as aided by the loop pressurizer will be 2,200 psi @ 600°F.

The pumps shall be capable of withstanding thermal shock from a rapid loop shutdown where 570°F loop water would be replaced by water at 70°F to 200°F. The thermal shock time is estimated at 300°F decrease - in 20 seconds. The frequency of rapid shutdowns is estimated four per year.

The pump type will not be limited by this criteria. The pumps may be vertical shaft, canned rotor, or horizontal shaft mechanical seal type pumps. The pumps may be single or multi-stage centrifugal with horizontal or vertical discharge. Suction and discharge connectors shall be constructed of 300 series stainless steel and designed for connection to 2 1/2 inch pipe with 2500 psi ASA rated flanges. A spare pump will be provided for each loop.

The maximum pump and motor set base plate dimensions will be 4 ft. by 9 ft.

Heat Exchangers - New heat exchangers will be required. The heat exchanger capacity and size was established by the requirement that the loop shall be capable of low pressure recirculation at a full tube power of 3800 KW and a maximum tube outlet temperature of 266°F, as presently outlined in the Process Standards, Reactor. This will permit the loop to be on standby while maintenance is performed on a pump without enforcing a 105-KE outage. Loop flows would remain at the nominal operating value.

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Secondary raw water cooling temperature shall be considered as 70°F. Heat exchanger fouling factors shall be chosen at 0.003. Heat exchanger operating duty will be 13.0 million Btu/hr.

The heat exchanger will be of the multitube, multi-pass, floating head type. In-line counter-flow parallel pipe type heat exchangers as presently installed are not feasible for the low operating log mean Δt .

The design of the heat exchangers shall be in accordance with the practices outlined in the "Standards of Tubular Exchanger Manufacturers Association", ASME, Unfired Pressure Vessel Code, Section VIII and American Standards Association Power Piping Code ASA B 31.1.

The maximum projected floor area of the heat exchangers and supports will be 4 ft by 22 ft.

Three-Way Control and Throttling Valves

The pump discharge one inch throttling DOV valves will be replaced in loops #3 and #4 with an equivalent valve of 60 psig pressure drop at 80,000 lbs/hr flow and with provisions for adjustable minimum flow. The 1 1/2" trim in the two 2 inch flow diversion DOV valves in loops #3 and #4 will be replaced with a 2 inch valve trim of similar design. These valves are:

1. Loop to emergency storage tank diversion valve.
2. Primary heat exchanger by-pass valve.

The loop dump port may require resizing to allow the loop to depressurize, during an emergency dump, such as a low-low trip, in a short enough time to prevent fuel element burn-out.

3.04.2 Modifications to Loops #1 and #2

The loops 1 and 2 tube flows and operating tube powers will be increased. The existing process tubes and nozzle equipment will not be modified. New recirculating pumps and primary heat exchangers will be required for the operating conditions outlined in section 3.03.

Recirculating Process Pumps - The new pumps will be designed for the following estimated operating requirements:

1,000 ft. TDH @ 100 gpm and 400°F water.

The design criteria and general requirements, other than above, for the loops #1 and #2 pumps will be as outlined for the loops #3 and #4 two pump operation.

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Heat Exchangers - New heat exchangers will be required for the #1 and #2 loops. The total operating duty will be 7.5×10^6 Btu/hr. at the same maximum inlet temperature of 266°F during stand-by loop operation as for loops #3 and #4. However, due to the proportionately higher tube powers with respect to tube flows in loops #1 and #2 as compared to loops #3 and #4, the log mean Δ is lower. This will require even larger heat exchanger surface areas. Study has shown that one feasible method of handling the problem is to provide two individual series exchangers per loop. Heat exchanger No. 1 would handle 90% of the total loop duty. The remaining 10% would be cooled by exchanger No. 2.

The two exchangers may be stacked parallel to the floor with one centerline above the other.

All other heat exchanger criteria will be the same as covered for loops #3 and #4.

3.04.3 Process Heat Exchanger Raw Water Pump and Back-Up Pump

The new loop process heat exchangers will require greater secondary cooling water flows than presently used. The heat exchanger cooling water is supplied from a raw water line that is manifolded to each cell.

The existing raw water pump is located in the 1706-KE pump room. The existing pump TDH is insufficient to provide the necessary total raw water flow.

This pump will be replaced by a 220 ft. TDH @ 3,000 gpm pump using the existing 200 hp motor.

All facilities serviced with raw water other than the primary heat exchangers will be checked and fitted with fittings for 150 lb. class pressure rating.

To provide cooling water backup in the advent of pump failure or maintenance, a back-up pump of similar capacity will be installed in parallel to operate simultaneously with the new replacement pump.

To obtain floor space for the new back-up pump, the existing filter bed backwash pump, that is not being used, will be removed. The new pump pedestal will be formed around the existing backwash pump concrete base.

To reduce system head losses, the raw water supply manifold piping in the south corridor and in each cell will be replaced with larger sizes. The six inch pipe will be replaced with 8 inch and the 4 inch pipe with six inch pipe.

3.04.4 Emergency Process Back-Up Water Piping Modifications

To increase available emergency process back-up water flow to loops #3 and #4, the jumper piping, check valves, and DOV

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process water control valves will be replaced from 1 1/2 inch size to 2 1/2 inch size. The existing 4 inch manifold and supply pipe will be replaced with 6 inch pipe. The existing manifold 4 inch gate valves used for strainer isolation will be replaced with six inch valves.

In addition to the existing emergency inlet side tie-in piping, which provides water for a downstream loop dump or outlet connector pipe rupture, a similar system will be provided and tied into the outlet side loop piping. This will provide cooling water protection in the advent of an inlet connector failure. The system would be composed of double check valves off of the loop, and a DOV valve.

The outlet emergency DOV would be normally open and would fail closed. The control and air supply for this valve will be tied into the control and air supply of the loop dump valve so that it will automatically close upon the opening of the loop dump valve. This would prevent the emergency water from by-passing the loop process tube during normal single pass operation.

The inlet and outlet emergency water DOV's will both remain open following a rupture of either the front or rear connectors. The supply manifold pressure has been calculated to be sufficient to provide the necessary flow for decay cooling, simultaneously, through the inlet emergency piping and process tube as well as through the outlet emergency piping and outlet connector rupture.

An inlet connector rupture would be carried by the manifold piping as outlined above.

The inlet DOV will be designed to fail open where the outlet DOV will fail closed. This will maintain the present loop protection standard of emergency cooling for a low-low flow loop dump.

3.04.5 Loop No. 2 Demineralized Water Pump and Supply Piping Additions

At present, when the loops are shut down for pump maintenance, it is necessary to change to single pass flow. The loop tube is cooled by using the emergency process water back up supply. This, however, requires that all corrosion tests in progress must be discontinued.

To permit continuation of corrosion tests during a loop and KE reactor outage, a demineralized water supply will be provided to loop No. 2 only.

The system will consist of a 350 ft. TDH pump at 20 gpm and 70°F water. The pump will be located in the KER make-up System room where the pump suction will be tied into the 1706-KE DW line in the make-up Room.

A 1 inch stainless steel pump discharge line will be routed from the make-up room into the south corridor, through cell #1

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and into the north corridor and will be tied into loop #2 inlet side piping, downstream of the loop blocking valves. Double check and pump isolating gate valves will be provided in the 1 inch line.

The high pump discharge head will keep the emergency process water check valves closed against shutdown pressures thereby preventing loop contamination yet will still retain the emergency process water protection if the demineralized water pump fails.

3.05 Electrical Criteria

3.05.1 Primary Power System Description

The power system arrangement is shown on one line diagram, scope drawing SK-1-22546. The primary source of power will be 4.16 KV. The power will be transformed to 480 volts for supply to existing motor control centers at 1706-KER.

One primary power source (4.16 KV) will be supplied from emergency bus C and bus F in 165 KE building switchgear. This power source will connect to a new 750 KVA transformer to be located at 1706-KER substation. At the 165-KE switchgear, existing breakers 32 and 32A are to be used as the power source connection. The existing 1500 HP raw water pump #4 is to be moved to bus D and a new breaker provided on the bus for service to the raw water pump motor. All existing instruments and control required for the raw water pump will be moved to the new cubicle position on bus D.

One primary power source (4.16 KV) will be supplied from emergency bus C and bus F in 165 KW building switchgear. As in KE area, existing breakers 32 and 32A are to be used as the power source connection with raw water pump #4 being supplied from a new breaker connected to bus D. The 4.16 KV feeder will run through the cross tie tunnel cable trays to 165 KE and connect to an isolated bus in 165 KE through a separate 4.16 KV circuit breaker. The isolated bus will also be fed from a new 4.16 KV breaker supplied from bus A. The isolated bus will be connected directly to a new 750 KVA transformer to be located at 1706-KER substation. Normally power will be fed to the isolated bus from 165 KW power system over the 4.16 KV system. In the event of an outage in 165 KW, by manual switching, power will be supplied to the isolated bus from bus A in 165 KE switchgear. Relaying will be common to these two breakers and suitable for transformer feeder application. Electrical interlocking will be required to prevent the closure of both breakers at the same time.

3.05.2 Alternate Primary Power Systems

With the completion of project CG-775, major modifications will have been made to the 4.16 KV power systems. These power systems changes will affect the planning for power connections to supply 1706-KER. Since the construction schedule of these two projects reflect the same completion

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date, an alternate primary power system for Project CG-839 will be adopted for use providing approval for design and construction of Project CG-775 is granted.

The alternate primary power system will have the same connections to the C and F buses in both KE and KW areas. Cubicles 32 and 32 A on buses C & F will be left as spares, after completion of project CG-775. These cubicles can be used for power supply to 1706-KER, although new replacement drawout 5 KV air circuit breakers will be required for the four existing positions.

The normal 4.16 KV power service required for the isolated bus in 165-KE will be supplied from a new 4.16 KV bus. This bus will be an outboard extension from bus A or D and provided as part of the system expansion under project CG-775. All available space on existing buses A and D will be used for Project CG-775. A new cubicle and circuit breaker will be added to the new bus with power and control as outlined for the original power plan.

3.05.3 Substation

All power transformers shall be outdoor oil-filtered type located adjacent to the existing 1706-KE substation. Primary and secondary connections shall be in conduit to transformer metal enclosed junction boxes. The transformer shall have delta connected high voltage winding and wye connected low voltage winding with the neutral bushing terminated in the low voltage terminal box. The transformer 480 volt secondary shall feed through a main air circuit breaker to the existing motor control centers in 1706-KER.

3.05.4 Motor Control Centers

Motor control center #6 will be supplied from the new transformer whose normal primary source is from 165-KW. Motor control center #7 will be supplied from the new transformer whose normal primary power source is from 165-KE. Motor control centers number 6 and 7 will supply power to circulating loop motors 1, 2, 3, and 4. Larger combination starter units will be required to handle the larger motor drives. All existing control units on control centers number 6 and 7 not required for service to the loops will be moved to motor control center number 8. This will permit the installation of the larger motor starter units in motor control center 6 and 7 within the limited space available.

3.05.5 Pump Motor Feeder and Control Wire Changes

With increased size primary coolant pumps for loop service, the size of service conductors will have to be increased. Control wiring will be modified to suit the specific conditions.

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3.05.6 Raw Water Supply

A new combination motor starter cubicle MCC #5 will be required in 1706-KE building for service to a new 200 HP raw water pump. The new motor starter will be supplied from switchgear breaker number 6, which now supplies the dowtherm heaters. The breaker trip circuit shall be adjusted to carry the combined loads of the 200 HP motor and dowtherm heaters.

3.05.7 Demineralized Water Pump

A new combination motor starter and power and control wiring will be added for service to a new 3 HP demineralized water pump.

3.05.8 5 KV Switchgear

All switchgear units to be added to the existing 5 KV switchgear in 165 building shall be of the same design and rating as the existing equipment listed in BPF-7413.

3.05.9 Fans for 5000 KVA Transformer for Bus D

Fans will be required before the raw water pump #4 can be transferred to bus D. Additional load of the #4 raw water pump will cause the total transformer load to exceed its 5000 KVA air cooled rating. The forced air rating with the fans will be 6250 KVA. This will provide adequate transformer capacity.

3.05.10 Electrical Design Codes

The electrical design shall conform to the latest revision of the following standards:

1. National Electrical Code
2. National Electrical Safety Code
3. Applicable HW Electrical Standards

3.06 Instrumentation Criteria

3.06.1 Primary Pump Instrumentation

1. Differential Pressure

The differential pressure across each pump shall be measured and indicated in the south corridor. Alarm contacts, with the trip point adjustable to 25% to 75% of maximum pump head, shall be provided. Loss of any one pump shall trip an annunciator in the 1706-KE and 105-KE control rooms. Loss of both pumps in any loop shall cause an immediate reactor shutdown.

2. Cooling Water

Flow switches shall be provided in the pump cooling water lines to operate an alarm on loss of flow. In addition, a

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temperature indicator alarm device, with the indicating instrument located in the south corridor, shall be provided. All pump cooling water flow and temperature alarms for each cell shall be paralleled to operate one annunciator in the 1706-KE control room. Readout of individual pump cooling water temperature is required.

3. Vibration Monitoring

Vibration sensing devices shall be provided on each primary pump to monitor pump vibration. A vibration indicator and selector switch, capable of monitoring any selected vibration sensing device, shall be located outside the cells. The location of the indicator and switch assembly shall permit convenient access to vibration information.

4. Equipment Location

All equipment connected to loop water piping shall be installed in the enclosures presently used for sampling lines. Temperature indicators, vibration readout equipment, etc. having no direct process connections should be mounted outside of the enclosures.

3.06.2 Rupture Detection System

1. System Function

The present rupture detection system consists of a neutron chamber installed in each of the four loops. Activity levels are recorded and indicated in 1706-KE and 105-KE control rooms, respectively. Alarm contacts in the indicators of each channel provide high and low trip annunciation in both 1706-KE and 105-KE. To reduce the probability of reactor shutdowns caused by equipment failure, there will be installed a coincidence system safety circuit. This will consist of adding an additional neutron counting channel to each loop and connecting both the high and low 105-KE indicator contacts into the coincidence safety circuit. The contacts of the two parallel channels shall be inter-connected to cause a loop and reactor shutdown under the following conditions:

- a. A coincident high trip of both channels in any loop.
- b. A coincident high trip of one channel and low trip of the parallel channel on any loop.

A single high or low trip or two coincident low trips (both channels) will actuate annunciators in both the 1706-KE and 105-KE control rooms. Provisions will be made to indicate which loop tripped the annunciator first when more than one loop has a high activity reading.

2. Log Count Rate Meters

The new channels shall utilize log count rate meters to allow an increased minimum reading under normal background conditions and increased spacing between low and high trips. The range of 10 counts per minute to 10 million counts per minute will be made available. On-scale readings should thus be obtained even during abnormal conditions.

3. Equipment Location

The moderator tanks that contain the neutron chambers for loops 1 and 3 will be moved downstream past the point where the dump valves of loops 2 and 4 are located to reduce interaction of neutron fluxes. Added isolation will also be provided around the detectors for loops 2 and 4. Preamplifiers for each of the new neutron monitor chambers will be located on or near the respective moderate tanks in 1706 KER. A new panel, located in the 1706-KE control room, will contain the new log count rate meters, radiation recorders and a high voltage power supply.

The coincidence relay matrix will be located in the new Recirculation Test Facilities Panel in 105-KE control room. Also located on this panel will be new radiation indicators and the associated annunciation circuits.

3.06.3 Water Sampling

1. High Temperature Sampling

A high temperature sampling line will be provided on each loop. The sample flow rate shall be maintained constant during the sampling period. The controlled flow rate for each sample line shall be indicated in the hot laboratory with an accuracy of plus or minus 5% of reading, or better.

2. pH Sampling

The pH of each loop shall be sampled continuously. The pH signals from all four loops shall be recorded on a four-point strip chart recorder located in the hot laboratory. The pH of each loop shall be recorded at least once per minute (the switching interval shall be 15 seconds, maximum). The sample flow rate shall be wasted and shall be chosen to minimize loop makeup requirements while allowing sufficient speed of response in the pH sampling system.

3. Equipment Location

Sampling equipment located in the Hot Laboratory will be mounted in a four-compartment laboratory hood similar to Dwg. No. SK-1-22045. Each sampling compartment will contain: (1) hot sampling facilities with provision for three sample bombs and for insertion of "hot crud probes", (2) the flow-

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metering facilities for the hot sampling lines, (3) pH sampling cells and pH sample flow regulating equipment and (4) cold sampling facilities with provision for drawing samples of up to one gallon in volume.

The pH and flow equipment which is not directly connected to the process piping shall be mounted on an instrument panel located in the Hot Laboratory. Any device which can come in contact with loop water shall be mounted in the sampling compartment.

3.06.4 Main Loop Flow Metering and Control

1. Flow Metering

Existing flow-metering equipment shall be modified to accommodate the high flow ranges. New orifices will be required on the (1) main loop flow, (2) mock-up bypass flow and (3) 105-KE inlet flow assemblies. New scales will be required on the associated flow recorders and indicators. The flow-meters will be calibrated to read directly in gallons per minute with a water specific gravity of 1.0. This is in accordance with present practice on these loops and specific instructions are available for correction for any temperature up to 300C. Full scale ranges for the three specified flow-meter shall be as follows:

Loops 1 and 2: 125 gpm
Loops 3 and 4: 250 gpm

2. Flow Control

The main loop flow control valves on each loop (DOV-408-4) shall be replaced with new valves sized for the new flow and pressure drop conditions. New trim may be required on DOV-3 and DOV-5 valves.

3.06.5 Primary Heat Exchanger Instrumentation

Temperatures

Three accurate temperature measurements are required to obtain heat balance data on the primary heat exchangers:

1. Heat exchanger inlet temperature
2. Heat exchanger outlet temperature
3. Loop temperature, after mixing bypass and heat exchanger flows.

Measurements 1 and 3 above are presently provided in conjunction with the loop temperature and pressurizer level control systems. The accuracy of the present systems is not adequate to provide reliable heat balance data. Therefore, two alternatives exist.

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1. Improve the accuracy of measurements 1 and 3 and add a new outlet temperature detector. A four-point temperature indicator and selector switch, located in the south corridor, would be required to read the outlet temperatures.
2. Install new temperature elements for all three locations (per loop) and read out all twelve temperatures on an indicator in the south corridor.

The costs of the two systems are comparable and the actual method used will depend on which system can provide better overall heat balance data and operator convenience.

The remainder of the temperature instrumentation provided on the existing primary heat exchangers shall be adapted to the new primary heat exchangers.

Differential pressure indicators are to be provided on the primary heat exchanger high pressure lines to indicate heat exchanger pressure drops. Local readout will be adequate.

3.06.6 Demineralized Water for Shutdown Flow

Demineralized water will be made available to provide the shutdown flow requirements of the process tubes for Loop No. 2. The flow of demineralized water in the loop shall be automatically controlled. Each flow control system shall consist of a flow transmitter and control valve located in the 1706-KER tunnel and flow recorder-controller located on the existing "Miscellaneous Panel B" in the 1706-KE control room.

Each flow control system shall have a range of 0 to 20 gpm. The recorder shall be equipped with low-flow alarm contacts, adjustable over a minimum range of 5 to 20 gpm, which will actuate an annunciator in the 1706-KE control room.

In addition, a stem switch will be provided on the manual shutoff valve (HV-15) to actuate an annunciator in the event the valve is left open during demineralized water operation.

3.06.7 Dump Valve Leakage Indicator

A temperature sensing element shall be provided on the dump valve drain lines of each loop to detect dump valve leakage. A four-point temperature indicator shall be provided on the 1706-KE control panel.

3.06.8 Process Water Backup System

The present process water control valves (DOV-13) are to be replaced with larger valves as required for adequate backup flow. The valves and associated manual control equipment shall be designed to permit reliable adjustment of the flow rates required for one-pass operation.

3.06.9 Process Tube Temperature and Pressure

New temperature and pressure sensing elements shall be provided as required to match the new process tube pigtail configurations.

3.06.10 Heat Exchanger Cooling Water

The increased cooling water flow rates required by the new primary heat exchangers will necessitate replacement of the measuring orifices in these lines. The new range requirements will be dictated by the heat exchanger design and shall provide a maximum flow reading approximately ten (10) percent in excess of the maximum flow requirement.

The cooling water flow control valves shall be replaced with larger valves sized to provide the maximum requirements.

3.06.11 Emergency Back-Flow Water Supply

A cross-tie line between the process water back up supply line and the process tube effluent line will be provided on each loop as shown on Drawing no. SK-1-22548. A remotely-operated diaphragm control valve, DOV-14, shall be provided to facilitate start-up and shutdown operation. DOV-14 will be interlocked with the dump valve, DOV-1, as follows: DOV-14 shall be open during normal recirculation operation of the loop. It will close whenever the dump valve is opened to drain. A manual bypass switch shall be provided to allow closure of DOV-14 during loop startup, prior to reactor startup. A stem switch on DOV-14 will indicate its position and actuate an audible alarm if the valve is closed.

If a piping break occurs on the front face, process water will be routed via DOV-14, through the process tube to the piping break, thus providing process tube cooling water until the heat source is removed. The process water control valves shall be sized to ensure that the minimum cooling water requirement is supplied to the process tube under both normal and emergency conditions.

To prevent tripping the inlet-pressure pressure switch, PS-1, and as a consequence, tripping the dump valve if a front face piping break occurs, the PS-1 contact will be activated only during a high-level radiation trip signal (actuation of TDR relay contacts).

3.06.12 Primary Pump-Dump Valve Interlock

Since the new primary pumps will have a total dynamic head equal to or greater than the process water pressure, it is necessary to modify the existing loop shutdown procedure. To prevent draining the pressurizer and damaging the pumps, an interlock shall be provided between the dump valve and pump circuits to shut off the pumps whenever the dump valve is opened to drain. The pumps must then be started manually after the dump valve is closed. An indicating light shall be provided on

the 1706-KE control panel to indicate dump valve position. A bypass switch shall be provided to allow operation of the pumps independently of the dump valve during reactor shutdowns, or on single pass flow with the loop test bypass valve open.

The high pump TDH will require that the switch setting on pressure switch PS-1 be changed.

3.06.13 Instrumentation Electrical Power Supply

The induction motor now used to operate the instrumentation power supply (motor-generator set) shall be replaced with a synchronous motor and the required switchgear. The new switchgear shall be compatible with the existing system and shall not alter the emergency backup power function provided on the present system.

3.06.14 Instrument Modifications for Increased Reliability

The 1706-KER instrument panels in the 1706-KE building shall be provided with forced-air cooling to increase their reliability. In addition, new power supply components shall be installed in all Swartwout control system components, as recommended by the Swartwout Company, to increase loop operating continuity and reliability.

3.06.15 Loop Contamination

The capacities of the emergency storage tanks are 500 gallons. After the installation of the #3 and #4 cell pumps, these loop flows will be as high as 200 gpm. This means that the storage tanks will have had a complete change of water in 2 to 2 1/2 minutes after the loop has been switched into the tanks following a fuel element rupture scram sequence.

To prevent contamination of the loop cells and high front face 105-KE radiation levels, a gamma monitoring system will be provided at the exit of each loop storage tank. The gamma signal will notify the control room that the loop should be dumped to single pass, even though the loop depressurization cycle has not yet been completed.

3.07 Architectural Criteria - Hot Maintenance Shop and Decontamination Room

3.07.1 General

The design criteria included herein is for a decontamination and hot maintenance shop with a floor area of approximately 1050 sq. ft. The building is to be a below-grade addition to the west end of the 1706-KER building. Drawing SK-1-22552 shows the scope of the proposed addition and building modifications.

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3.07.2 Work Description

1. Building Addition

The floor, wall, and ceiling of the addition shall be constructed of reinforced concrete. Roofing shall be built-up type. A roof hatch and hoist facility shall be provided for equipment entry and removal. Electrical lighting and power, heating, and ventilation, and utility services shall be provided as required to make a complete and operable facility.

2. Building Alterations

Alterations to the existing building consists of framing in two new doors into existing concrete walls and relocating interferring electrical work, and relocation of a sump man-hole. The existing above grade contaminated clothing storage addition shall be dismantled and re-installed upon completion of the below grade work. The existing gas cylinder station installation shall be similarly handled.

3.07.3 General Building Design

3.07.3.1 Architectural

1. Foundations shall bear on undisturbed soil.
2. The building shall be constructed of reinforced concrete. Interior surfaces of walls, ceiling, and floor shall be finished with a decontaminable and chemical resistance paint.
3. Roof shall be provided with 1-1/2" of mineral type rigid insulation. Roof shall be sloped to provided adequate drainage. Roofing shall be a 20 year built-up tar and gravel or the equivalent asphalt and gravel type as noted in the Hanford Works Standards.
4. Live loading of 75 lb./sq. ft. shall be used in the design of the new roof. The new floor of the contaminated clothing storage addition shall be designed for 100 lbs./sq. ft. live load.
5. Steel posts embedded in concrete shall be used to provide protection against inadvertent vehicle traffic on the new roof.
6. Provide a roof hatch with a 4'0" x 10'0" clear opening. The cover shall consist of three equal sections each provided with lifting lugs for hoist removal.
7. A motor driven hoist, with the necessary steel framing support and track, shall be provided over the roof hatch.

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The hoist shall be a chain lift and chain operated travel type of 1-ton capacity and with a clear height from hook to top of hatch of 10'0". Provide a swing jib, hinged to the track extending 5'0" out into the road and capable of being swung 90° and latched free of the road right-of-way.

8. A cart accessway shall be provided for servicing the gas cylinder station. This shall be designed to protect the roofing from damage.

3.07.3.2 Equipment & Furnishings

1. The storage cave shielding door shall be constructed of laminated steel plates with a total thickness of 7" and shall lap opening 6" at top and sides. The door shall be a power operated slide type with emergency stop safety edge strip. Push button controls shall be constant pressure type. The cave inner door shall be flush hollow metal type completely weatherstripped to prevent airborne spread of radioactive contaminants.
2. Shelving shall be provided and will consist of steel construction with the assembly consisting of units 2'0" deep, 3'0" wide and 14'0" high with backs and unit end panels.
3. Work benches shall be provided and will consist of steel construction with steel tops 2'6" x 5'0" long. These shall be provided with removable wood working surfaces of 3/4" thick D. F. plywood fastened to the metal tops with bevel-headed bolts.
4. The 2'10" high welding bench shall be of steel construction with 4'0" x 4'0" steel top.
5. Drill press - Buffalo No. 22, Round column floor.
6. Bench grinder - "Queen City Model 10F-440 volt, 3 HP."

3.07.3.3 Mechanical

1. The work to be accomplished under this criteria covers ventilation supply and exhaust, service piping, and decontamination tank relocation and exhaust for the Decontamination Room and Maintenance Hot Shop addition to 1706-KER facility.
2. Ventilation Supply
 - a. Ventilation supply shall be obtained from existing supply fans by increasing their discharge capacity. This can be accomplished by increasing the fan rpm. and miscellaneous system adjustments.

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- b. The 16" x 16" duct section located near the west end of the south corridor (Ref. H-1-20361 KE) shall be increased in size to carry the additional air supply to the Decontamination Room. Consideration should be given to the control damper and duct sizing adjacent to the fan area.

3. Cooling

The cooling load shall be based on an outside air temperature of 103° db, 67° wb with supply air at 70° db and 90% saturated. The room temperature of the north corridor and the cell adjoining the east side of the decontamination room is approximately 120°F db.

4. Heating

The room shall be heated by warm air supplied from the main supply units. No additional reheat coils are anticipated as being required.

5. Decontamination Tanks

The four existing decontamination tanks which are located in the pipe tunnel between the 1706-KER and 105-KE buildings shall be relocated as shown on Drawing SK-1-22552. The existing stainless steel exhaust ducts over the tanks shall be removed, modified as required, and reinstalled to provide exhaust from each of the tanks.

6. Welding Table Exhaust Hood

A stainless steel exhaust hood shall be designed for over the welding table.

7. Decontamination Exhaust System

The exhaust air from the decontamination tanks and from the welding bench shall be carried through stainless steel ducts by an exhaust fan of stainless steel construction. The exhaust air will be passed through CWS type filters and discharged to the atmosphere. The exhaust fan and filter section may be mounted on the roof of the decontamination room.

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8. Sink Piping

The steel sink shall be supplied with hot and cold sanitary water from the most convenient source. (Ref. Drawing H-1-20357 KE).

9. Safety Shower

A safety shower shall be installed in the vicinity of the decontamination tanks. This shower shall comply with G. E. Mechanical Standard B-3-7 "Safety Shower For Heated Installations" and shall be supplied with cold sanitary water.

10. Floor Drains

Two floor drains shall be provided in the room. These drains shall be connected to the existing building drainage system. (Ref. Drawing H-1-20355 KE).

11. Manhole Opening

The manhole opening in the west end of the north corridor (Ref. Drawing H-1-20355 KE and H-1-20375 KE Detail 209) shall be modified to eliminate any obstruction above the floor level while retaining access to the drainage pit.

12. Decontamination Tank Piping

Piping for the decontamination tanks shall provide cold water supply and a selection drainage system.

- a. The cold water supply shall be piped in from the most convenient service water supply source. (Ref. Drawing H-1-20357 KE)
- b. The drainage piping from the decontamination tanks shall provide for drainage from any tank into either the building drainage system or into the drainage lines leading to the crib. This system shall provide convenient selectivity.
- c. The cleaning solutions in the tanks may be caustic or acidic, including 30% nitric acid solution.

13. Compressed Air Supply

Compressed instrument quality (filtered) air shall be supplied to the area of the work bench, bench grinder and decontamination tank agitator. (Ref. Drawing H-1-20357 KE)

14. Relocation of Existing Equipment in Chem. Lab.

The exhaust filter manometer panel and the R.M. sample station located on the N. wall of the chemical laboratory shall be removed and relocated to provide a clear doorway area into the Decontamination Room. (Ref. Drawing H-1-20364 KE, H-1-20357 KE, H-4-1645, H-4-50400). This equipment may be shifted toward the east wall of the laboratory to clear the doorway.

15. Materials

Where possible, all ductwork, supply outlets, turning vanes, dampers, air test stations, fan installations, piping, etc., shall be compatible with existing equipment.

16. Vacuum Dust & Chip Collection

The metal working machines shall have provisions for collecting chips to control room contamination. The bench grinder shall have a vacuum dust collector.

3.07.3.4 Electrical

1. Grounding Protection

The building ground grid system shall be extended and added to the additional building structure. System equipment grounding shall follow the recommendations of the National Electrical Code, and HW Standards SDC-7.5, Section G.

2. Motors

Motors shall be conventional design with drip-proof enclosures for indoor installations and totally enclosed types for outdoor and wet locations. Motors 1/2 HP and larger shall be operated on 440 volt three phase power systems. Motors 1/3 HP and less shall be operated on 120 volt single phase power systems.

3. 440 Volt Power Supply

Normal 440 volt power supply shall be from a 100 ampere plug-in-busway section to be mounted in the hot shop. Power supply to the plug-in-busway will be from motor control center #10 in 1706-KER Building. A four pole busway shall be specified with the fourth pole to be used for equipment grounding.

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4. 120 Volt Power Supply

Power supply to small motors less than 1/2 HP and electric heaters shall be from spare circuits in lighting panel "JY" located in the south corridor of the 1706-KER building. Four 20 ampere convenience outlets shall be located over the work bench. Four located on opposite wall.

5. Illumination

Lighting intensity and quality as recommended by the Illuminating Engineering Society shall be provided. Fixtures shall be standard industrial, fluorescent type. Power for lighting circuits shall be taken from panel "JY" in south corridor of 1706-KER Building.

6. Intercommunication System

The existing 1706-KER building intercommunication system shall be extended to provide communication to the new building addition.

One speaker and microphone will be required for the hot shop. Equipment shall match existing communication equipment and shall connect to communication control panel located in 1706-KER building.

Existing Equipment:

Amplifier	-	Stromberg Carlson Model AP-55
Pre-amplifier	-	Stromberg Carlson Model AV-52
Speaker	-	University Model
Mike	-	Turner dynamic Model FR-15, 500 chms.

7. Welding Power Supply

A welding service outlet will be provided at the location of the welding bench in the hot lab. The existing welding outlet located in the hot shop will be moved to the welding bench. For type and location of existing welding equipment see reference drawing SK-1-22044.

8. Regulated Voltage Supply

A 120 volt, 60 cycle electrical supply outlet shall be provided over the work bench. The type of outlet will be in accordance to HW Standard D-1-24. Service to the outlet will be from the regulated voltage panel located in 1706-KE control room.

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9. Radiation Monitoring Annunciator

A remote radiation monitoring system shall be installed in the decontamination room and in the maintenance shop. The monitor shall have an audible annunciator. The monitor shall be similar to the HM Chamber - Beckman or the Victoreen RAMS Systems.

3.07.3.5 Reference Standards

The design should conform to HAPO approved Codes, Standards, and Design Guides. The following should be made available for use by the A. E.:

HWS-10000 - Architectural and Civil Standards
HWS-10001 - Mechanical Standards
HWS-10002 - Electrical Standards
HWS-10003 - Design Guides
HWS-10004 - Welding Standards
SDC-1.2 - Std. Design Criteria for Codes, Stds., and Specifications.

4.0 BIBLIOGRAPHY

<u>Document No.</u>	<u>Title</u>	<u>Author</u>	<u>Date</u>
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HW-58936	Scope and Justification Modification to 1706-KER Fuel Element Test Facilities	LB Brinkman ML Faught	February 24, 1959
HW-58609	Modification of the 1706-KER Loops - Proposed Scope and Justification	AC Callen	December 19, 1958
HW-55900	Flow and Heat Transfer Analysis of the KER Loops	SS Jones JE Hammond	April 30, 1958

5.0 REFERENCE DRAWINGS

SK-1-22546 - Electrical One Line Diagram
SK-1-22548 - Instrumentation Engineering Diagram
SK-1-22550 - Piping, Pumps, and Heat Exchanger Modifications
SK-1-22551 - KER Loops 3 and 4 Process Tube Assembly
SK-1-22552 - Proposed Decontamination Room and Maintenance Hot Shop

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END