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MINUTES

MASTER

HTGR-SC/C PROGRAM BASELINE REVIEW MEETING

SESSION IIC

CIRCULATORS, C&I, & HELIUM SERVICE

SAN DIEGO, CALIFORNIA

DECEMBER 9-11, 1981

MODERATOR: F. Swart
GCRA

SECRETARY: C. E. Forkel
EG&G Idaho, Inc.

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MAIN & AUXILIARY CIRCULATORS

PRESENTERS: D. Kapich (GA)
M. K. Nichols (GA)
C. Rodriguez (GA)
J. Vavrina (GA)

PART A

MAIN & AUXILIARY CIRCULATORS

The attendance and handouts for this presentation are attached at the end of these minutes for Part A of Session IIC.

I. INTRODUCTION

A brief introduction was made by the moderator, Fred Swart.

II. MAIN CIRCULATOR & LOOP ISOLATION VALVE (LIV) REQUIREMENTS

Davorin Kopich presented the portion of the handouts (viewgraphs) related to the requirements for the main circulator and its loop isolation valve. He emphasized that the safety classification of the circulator extended only to the primary coolant boundaries; including the seismic and motor failure aspects. In contrast, the function of the loop isolation valve is safety classified because the core auxiliary cooling system (CACS) requires that not more than one of the four main loop valves be open to prevent bypass around the core. There must be no instability at any point of operation or stack-up of margins which are 20% on the worst case differential pressure and 30% on the nominal design point.

III. MAIN CIRCULATOR & LIV DESIGN DESCRIPTION

III.a. The design description of the circulator and the loop isolation valve was presented by Davorin Kopich. The seismic response of the circulator and motor assembly has been analyzed and found to be satisfactory. The isolation valves have been found to close almost instantly from the Fort St. Vrain (FSV) experience. Proven technology is being emphasized in the design; particularly in regard to oil leaks which have been a major, general complaint in gas cooled reactors. This has resulted in the use of water lubricated circulator bearings within the primary boundary and oil lubricated bearings, including the thrust bearing, only in an electric motor outside the primary containment. The high power consumption, approximately 11.5 MW per circulator, and the recovery of only 40% of the energy supplied to the circulator dictates the use of a high efficiency motor; e.g., a synchronous motor. The motor should be within present technology because solid rotor generators have been made in sizes up to 1,000 MW. Both pipe and vane circulator diffusers are being considered; the selection may depend upon actual testing.

The isolation valve will make use of the same metallurgy and hard facing used at FSV to prevent self welding; this includes both the shaft and its bearing and the vanes upon which the blades come to rest in the closed position. The design also incorporates an added feature in the form of high pressure helium jets which blast against the blades to initiate operation of the valve when the loop flow has stopped on circulator coastdown. Additionally, a fiber optic device will monitor the position of the valve blades. The jets and fiber optics will be used in combination for in-service inspection (ISI) of the valve during operation of the circulator.

A water lubricated sliding mechanical seal is used at the primary system pressure boundary of the circulator shaft. The water temperature is low so there is no problem with cavitation. This seal is accessable for ISI by means of a removable spool between the motor and circulator shafts.

The circulator bearing water from the service module is pressured by a self contained pump driven by the circulator shaft. The water is then drained uphill for return to the module by three jet pumps, each of which is capable of removing all of the water.

The circulator service module is an improvement over the FSV module. It has no live modulating valves. It receives buffer helium and bearing water from the circulator, separates them, discharges the helium to the helium purification system for return to the circulator, and cools and returns the bearing water to the circulator. The buffer helium is taken from a header maintained at 15 psi above reactor pressure and metered to the circulator through a fixed orifice. The bearing water is cooled by a coil contained in the separator/surge tank.

For shutdown, an air operated brake prevents rotation of the impeller, a bellows energized by high pressure helium operates one of two shutdown shaft seals, and a mechanical shutdown scavange pump removes residual bearing water from the bearing module.

Mr. Kapich's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. P. Kasten - The primary seal at the closure flanges is of Code design and can be in-service inspected by monitoring the pressure in the buffer helium area between the two O-rings in the double seal. The buffer helium is pure.

2. V. Scotti - The primary closure bolts, which include two bayonet bolts for guides, are man accessable through the motor mount and could be in-service inspected, possibly by Zyglow, but the primary indication of any distortion would be by leakage of the buffer helium.

3. P. Kasten - The purpose of the two piece closure flange is primarily a question of forging size and also allows removal of the bearing cartridge from the larger closure flange.

4. P. Kasten - The speed of the circulator will be varied during operation to control the rate of helium flow.

5. P. Kasten - The speed of the circulator is varied to match the demand for steam. The rate of helium flow is thus controlled by the feed water rate via circulator speed. The minimum speed of the circulator is 5% of nominal design for hot restart.

6. Unknown - The isolation valve disk, or blade, comes to rest in the closed position upon the upper edge of vanes that span the valve body. It does not rest on the "seat" itself.

7. P. Kasten - The isolation valve is not kicked open by the helium jets. The blades are only blasted apart to close the valve. The jet helium pressure is 500 to 1000 psi above the reactor pressure and the blast duration is 3 sec.

8. L. Welshans - There is no mechanical device being considered for overriding the isolation valve. The feeling is that a mechanical device would cause more problems than it would solve; particularly with regard to an additional live seal on the primary cooling system. The jet produces a force of about 200 pounds on the valve blades.

9. L. Welshans - At FSV the isolation valve has stood open on shutdown but it was not stuck. With full power on four circulators at FSV, the valve closed almost instantly after stall head was reached on the tripped circulator. It is presently being considered to spread the blades to form an angle of about 3 degrees in the open position so that gravity will assist in closing the valve.

10. Unknown - The sliding mechanical seal is of the limited leakage type recently developed for cooling water pumps and boiler feed water pumps. It is both cooled and lubricated by the bearing water. Approximately 50 kW is lost through cooling of the upper seal.

11. P. Kasten - The seal water pressure is 1050 psig; about the same as the primary system.

12. L. Welshans - If the shutdown seal's bellows fails at FSV, the reactor is shutdown and the circulator is removed for repair. The new design for the SC/C circulator provides a redundant shutdown seal for backup.

13. Unknown - All scavenging helium is recovered by the circulator service module and the helium purification system.

14. K. Van Howe - The shutdown scavenge pump assures removal of bearing water on runback from the jet pump and during shutdown. A slinger on the circulator shaft acts as a pump impeller capable of holding a water pressure of 150 psi against the leakage of water into the reactor during circulator operation.

15. R. Stearns - The buffer helium in the circulator bearing cartridge is maintained at 1 psi above reactor pressure.

16. P. Kasten - It is not necessary to know the water pressure within the helium/water cavity of the bearing cartridge. The water pressure is controlled by the pressure of the buffer helium. It is the velocity of the buffer helium through the labyrinth rather than pressure drop which prevents moisture from entering the reactor and radioactive gas from entering the bearing cartridge.

17. K. Van Howe - The water level in the circulator service module surge tank is made up by a small, positive displacement pump with a counter for accuracy of control and recording the quantity of make up.

18. L. Welshans - If the circulator service module surge tank floods, water will be drained by overflow pots and redundant valves will shut off the supply of water.

19. P. Kasten - The purified helium header is maintained at 15 psi above reactor pressure. A fixed orifice meters the flow of buffer helium from the header to the bearing cartridge.

20. Unknown - Failure of the jet pump to function automatically starts the shutdown pump to remove water from bearing cartridge.

21. K. Van Howe - The sliding high pressure seal leaks at the rate of approximately 1 litre/hour. This water will probably be discharged to rad waste. It is of very low activity and the only drain from the entire system.

22. K. Van Howe - During startup, the surge tank provides for the expansion of the bearing water.

23. R. Stearns - The bearing water is cooled by a coil located inside the surge tank. The coil is supplied with reactor plant cooling water, which water is not safety classified.

24. V. Scotti - The capacity of the surge tank is expected to be about 500 gallons.

25. K. Van Howe - On shutdown of the circulator, the brake is applied to stop rotation, the shutdown seals are actuated, and the shutdown pump is run to remove all water drain-down from the bearing cartridge.

26. C. Dupen - The question of oil vs. water as a lubricant has been well researched. Oil has a very bad history - it is very difficult to remove from the reactor. Water has twice the specific heat of oil and has a 50% higher flow rate - 200 gpm for water vs. 120 gpm for oil on a 12 inch bearing. Additionally, water produces less friction than oil. This gives water the greater cooling capacity and the lower potential for grabbing.

27. P. Kasten - The use of gas lubricated bearings would require a submerged motor concept and high speed operation. It also gives a problem at depressurized conditions. Gas bearings were used on Dragon, but these were small, high speed (24,000 rpm) units operating at constant speed. The mass of the large horsepower SC/C circulators is not generally compatible with gas bearings. Submerged operation would require the use of an induction motor which is not as good as a synchronous motor for operation at variable speed.

28. C. Forkel - The shaft is caused to rotate by bearing water through the tangential flow producing a fluid shear force on the journal. At FSV this effect produces a speed of about 200 rpm. The point is that this speed coupled with the high mass of the motor necessitates stopping the rotation with the brake before actuating the shutdown seal.

29. V. Scotti - The fiber optics for the isolation valve position indicator is suitable for the pressure and temperature of the reactor environment, but some radiation shielding may be required. It will be a permanent installation. It has been very sucessful at FSV.

30. K. Van Howe - The fiber optics system is replaceable.

31. K. Van Howe - The in-service inspection (ISI) will consist of:

a) Monitoring the shaft orbit

b) Monitoring the main flange for leaks

c) Visual inspection of the main closure bolts

d) Monitoring the sliding water seal for excessive leaks

e) Checking with the fiber optic system, that the LIV will move when the closing helium jets are applied

f) Volumetric examination of the circulator when it is removed, III.b. The design description of the electric motor and solid state power supply was presented by Carmelo Rodriguez.

The motor is variable speed and is rated at 15,200 hp, producing a torque of 33,260 ft lbs. It has a vertical shaft and operates in the environment of the reactor building. It is cooled by air-to-water heat exchangers within the frame. The selection of the motor considered a direct current motor and both induction and synchronous alternating current motors. Direct current motors were eliminated because of size. The synchronous motor was selected over the induction motor because it provides better speed control, it is more efficient, and it is smaller. The rotor of the motor is solid and its field is energized by a brushless exciter and rotor mounted diodes. All brushes and slip rings have been eliminated. The motor provides the thrust bearing and the brake for the entire motor and circulator assembly. The bearings are of the oil lubricated, tilting pad type. A solid, removable coupling spool joins the circulator and motor shafts. This allows the motor to be removed and replaced without disturbing the alignment of the assembly. A computer model of the combined shafts has indicated that although the motor rotor has one critical speed within the circulator's operating range, the response is acceptable as a result of the damping of the bearings.

The variable frequency power supply is the main user of thyristors. The power supply for each circulator contains two, complete, three phase trains; each of which is capable of carrying full power for the circulator. The reconstructed variable frequency sine wave is approximated by 12 step changes per cycle. A design feature is that the thyristors can be serviced while at power. The power supply draws energy from the 13 kV plant power grid.

In the FSV experience with electrically driven feed water pumps, it was found necessary to make a very fast transfer between the normal power source and reserve power source (within approximately two cycles) so that the rotor at slow down will not lag the stator by more than 20 or 30 electrical degrees. Otherwise there will be a very high load on the rotor and bearings of the motor. A fast transfer of power source for the circulators will be a requirement on the balance of plant (BOP) for the SC/C plant. The experience in steel mills with this type of power supply has been 90% availability with only one thyristor train.

Viewgraph No. F-867(32) included in the attached handout lists a number of existing motors having characteristics similar to those required for the main helium circulator motor. Of particular interest are: (a) the Westinghouse synchronous 4-pole motor, (b) the two induction motors, and (c) the Siemans synchronous 18,000 hp motor. The Westinghouse motor is very close to the SC/C requirement for power and is slightly higher speed which makes the SC/C motor design easier. The induction motors' speed control is by switching on and off resistors that are in series with the rotor windings. This is inefficient, but the motors have been in operation for 20 years. The Siemens motor has been in operation for two years. The motors will be observed for their continued operational experience. Mr. Rodriguez emphasized that all of the motor features contained in the concept for the SC/C plant are in keeping with present technology for motors of the required size although they have not all been combined in the design of one motor.

Mr. Rodriguez's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - The bearing for the vertical motor is state-of-the-art. Many motor manufacturers have been contacted and none has made a motor with all of these characteristics; but many have made vertical motors of the same horsepower but not variable speed or horizontal motors with variable speed but not of this size. However, none of the potential suppliers anticipate difficulty in meeting all of the requirements.

2. C. Dupen - The critical circulator speed is higher than the operating range. Because of the higher mass of the motor shaft the motor has one critical speed, in the range of 800 to 1,000 rpm, that is within the operating range. The motor supplier has taken this into the consideration in the design of the motor. Because of external damping of the bearings; the response at the critical speed is 0.010 inch which is considered acceptable.

3. L. Welshans - It would be better if the circulator and motor were made by one vendor for a unified design, but there is a problem in getting a single vendor. However, GA has worked closely with the motor supplier for an integrated effort. Mr. Welshans remained uncomfortable in the fact that a motor combining all of the necessary features has not actually been built.

4. Unknown - The thrust bearing is of the Kingsbury type and double acting. It provides for an upward load of 40,000 lb and a downward load of 25,000 lb.

5. Unknown - Harmonic generation in the power supply does not have adverse effects on the operation of the motor. If one of the three thyristors fail, the output sine wave is further distorted; however, the motor is still capable of running with a number of the thyristors out of service. A ripple is produced in the power grid but the dc reactors in the power supply reduce the effect. Discussions with other users of this system in steel mills indicate the effect is livable.

6. Unknown - The effect of harmonic generation on the communication system is addressed in plant specification for the control and instrumentation system as a requirement.

7. Unknown - The reliability of the rotating diodes in the synchronous motor has been addressed by the motor manufacturers. They have 20 years experience on generators and are confident of the application to the motor.

8. C. Forkel - The "solid rotor" electric motor has a one forging rotor with slots cut in it. This term is in contradistinction to a "laminated rotor".

9. K. Van Howe - A spare motor is an unnecessary expense because the motor can be removed, transported to a shop, rewound, returned to the plant, and reinstalled within one week. There are numerous shops distributed around the country which rewind large motors of any make.

10. Unknown - Reinstallation of the motor can be accomplished without realignment because it is dowelled to the circulator with tapered pins as part of the original installation.

IV. MAIN CIRCULATOR DESIGN & TECHNOLOGY PLANS

IV.a. The overview network and program costs were presented by Michael K. Nichols. The technology plan details the things that need to be done to assure that the hardware will satisfy all of its requirements. Viewgraph No. 3221-2 shows that GA is well into the conceptual design of the main circulator, LIV, and circulator service system. In the later part of conceptual the initial prototype design will incorporate feedback from component tests, which will then proceed on the final design and construction of the prototype circulator, LIV, motor, and motor controller. This will be accomplished in the time frame of the plant Title I design. The prototype tests will be conducted during Title II design so that the production units can be completed for installation during Title III construction of the plant.

Mr. Nichols' response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - Each production unit circulator assembly will be acceptance tested in the circulator test facility before shipping to the plant site. The circulators will be tested separately at the test facility; not four at a time. The hot flow test of all four circulators will occur at the plant. The production motors will be acceptance tested at the plant site; not at the circulator test facility. The prototype motor will be retained at the test facility to drive the production unit circulator assemblies. The prototype circulator will test a complete motor, circulator, and motor module system together with all controls to the operator's panel. This will facilitate operators training with an exact duplicate of the plant control panel.

2. P. Kasten - The bearings and seals will be tested in the prototype circulator test in addition to the previous bearing and seal component test.

IV.b. The design data needs, technology development plan, the component and circulator power test, and the circulator test facility were presented by Michael K. Nichols. The material tests of an impeller forging of Type 410 stainless steel and welded Inconel-718 bellows, the bearing and seal test, the shutdown seal component test, the water/air sliding seal test, and the 1/3 scale aerodynamics test are all directed toward the design of a successful prototype circulator which will bring no surprises when tested in the full size prototype test facility. The prototype test will be full size and full power. The transient circulator tests will include service system transients. The noise level generated by the circulator in helium will be measured. The prototype test facility will be a modification of an existing GA facility that was used for Delmarva equipment tests.

Mr. Nichols' response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - A Type 410 stainless steel forging for the impeller is needed to assure the technology for producing sound forgings of the required size and which will have the required strength throughout its volume. It will be fracture mechanics tested. In the past these forgings have also been spin-tested. Licensing requires demonstration of adequate capability of burst protection.

2. L. Welshans - Quality of the production impellers will be assured by complete Zyglow inspection of each after the completion of fabrication.

3. L. Welshans - ASME Code approval of Inconel-718 is needed for the welded bellows on the shutdown seal. High cycle fatigue failure of the shutdown seal bellows was a problem at FSV. Mr. Welshans had no problem with testing the weldment but stated that Code approval could not be obtained for $481,000.

4. L. Welshans - The conditions for the bearing and seal component test differ from the real system in that the system will be unpressured. Cavitation in the bearing water pump is a greater problem when unpressured. When completed, this test should provide all the information needed for the final design of the prototype.

5. C. Forkel - The bearing and seal test rig in the viewgraph and Fig. 2 of review document No. 906252 is not prototypical with respect to the sliding water seal and the absence of the upper water lubricated sleeve bearing. It is believed that the sliding water seal should be the subject of a separate test program. The single bearing will be studied for off-balance loads at the bearing and its response to various speeds. Also, the bearing water pump

performance and its interaction with the bearing will be studied. The labyrinth seal for the water/helium interface will be exactly prototypical. Mr. Forkel continued to favor the maximum possible prototypicallity in the bearing and seal test.

6. K. Van Howe - Bearing loads for coupling misalignment will not be investigated in the bearing and seal test. The combined effect will be determined in the full scale prototype test.

7. L. Welshans - The aerodynamic test of the main helium circulator will be with air at room temperature - not heated. The test will checkout the diffuser design and show the effect of LIV malfunctions.

8. L. Welshans - The impeller will be checked out in the aerodynamic test. The main study will be of interactions between components and selection of the diffuser type. The performance map will be generated and the reverse bypass flow will be determined.

9. P. Kasten - Both lamniar and turbulent reverse flow will be experienced. The test will explore the effect of various valve positions.

10. P. Kasten - The diffuser will be designed for operation at normal conditions. The reverse flow characteristics of the diffuser will be explored for safety considerations. The test will be made with shaft fixed against rotation and again windmilling in reverse.

11. K. Van Howe - The brake will be designed to prevent windmilling in reverse.

12. P. Kasten - In addition to the diffuser design, the 1/3 scale aerodynamic tests will check the impeller design and the effect of the location of LIV. The primary objective of the test is to explore the interactions of the various components. The small scale tests are felt justified because modifications of full size parts for changes of design will be expensive in both time and money.

13. Unknown - In the priority designation, "1" is essential, "2" is for risk reduction, and "3" is for optimization.

14. L. Welshans - The prototype circulator test will be at full temperature and pressure with helium. The circulator heat input will be removed by a Dowtherm cooler.

15. K. Van Howe - In the prototype test all bellows seals will be prototypical and the bell-mouth steam generator-to-circulator duct (circulator inlet) will be duplicated.

16. K. Van Howe - The circulator inlet duct pressure drop for flow measurement purposes will be calibrated in a separate facility.

17. L. Welshans - The cost estimate of $5.85M for the prototype circulator test facility is based on reusing the existing GA facility. It is less than the $20M estimate for the gas cooled fast breeder reactor (GCFR) circulator test facility because the HTGR has a smaller motor and the GCFR facility was all new. The estimate is GA's - not Ralph M. Parsons. GA was not sure if the cost of the motor was included in the estimate and agreed to find out.

IV.c. The motor, controller, and instrumentation plan overview and the design data needs for same were presented by Carmelo Rodriguez. The control and instrumentation effort is divided into two categories - the main circulator motor controller and the controls for the rest of the system. The control effort has been integrated with the mechanical effort. Most of the controls and instrumentation for the primary system are carried by the overall plant control system and the plant protection system. However, there are some controls that are unique to the primary system that control and monitor the circulator service system that provides buffer helium and bearing water to the circulator bearing cartridge. Since the service system control is mostly passive, the active functions of this system consist of the surge tank liquid level control on the positive displacement makeup water pump and monitoring the water level in the circulator bearing cartridge to alert the operator to start the positive displacement scavenging pump to prevent water from ingressing the primary system.

Mr. Rodriguez's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. K. Van Howe - The motor contractor, not GA, does all of the design of the circulator motor and its controller. Fabrication of these components is not in viewgraph No. 3221-3 because they are capital cost equipment. GA's liaison includes computer modeling of the control system to assure its proper performance.

2. L. Welshans - The full scale mock-up of the control room is a new addition. It will exactly duplicate the control room with respect to all systems.

3. K. Van Howe - The backup bearing cartridge scavenging pump is started by loss of pressure drop across the jet pump.

4. K. Van Howe - There are no design data needs for the motor and its controller because the technology exists for all of the required features although they have not yet been assembled in the required combination.

5. K. Van Howe - The motor vendors have existing computer models that can be routinely changed to generate the parameters needed for the HTGR circulator motor.

This concludes the minutes for the presentation of the main helium circulator baseline design review.

V. AUXILIARY CIRCULATOR & AUXILIARY LOOP ISOLATION VALVE (ALIV) REQUIREMENTS

Davorin Kapich presented the portion of the handouts related to the requirements for the auxiliary circulator and its loop isolation valve. Since the core auxiliary cooling system is a backup to the main loops for removal of decay heat, both the circulator and the ALIV are safety classified in function. The circulator must be consistent with 10 CFR 50 requirements and have quick in-service inspection capability. It must be capable of circulating coolant at all zero power reactor conditions. Both the circulator and ALIV must remain functionally undamaged by the effects of earthquake, DBDA, and the ingress of steam or air. The ALIV must be passively and automatically actuated by helium flow, be provided with a manual assist to actuation, and be provided with a position indicator. Although diversity of the ALIV is not a present regulatory requirement, this is anticipated and GA has added the requirement that one of the three ALIV's be diverse in design.

Mr. Kapich's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - The ALIV is diverse from the LIV only in the use of gravity to open and the use of reverse flow to close with slight differential pressure. Both valves are of the same basic design.

2. F. Swart - By "slight differential pressure" to close the ALIV by reverse flow Mr. Kapich means "2% flow when pressurized and 10-15% flow when depressurized".

VI. AUXILIARY CIRCULATOR AND ALIV DESIGN DESCRIPTION

Davorin Kapich presented the portion of the handouts related to the description of the auxiliary circulator and ALIV design.

The selected drive motor has a frame capable of 800 hp, which is more than adequate for the actual requirement of 226 hp. An induction motor was selected over a synchronous motor from considerations of the motor being submerged in the primary reactor cooling system. The two primary factors were (a) the induction motor, being smaller, is more suitable to the cavity in the PCRV and (b) the diodes in the rotor of the synchronous motor are not suited to the environment. The motor is powered by a variable frequency power supply which is connected to both the plant and emergency power systems. By placing the motor inside the primary system, the need for a high pressure shaft seal has been eliminated. The circulator is completely within the pressure boundary and is not a part of the primary closure. A secondary closure is provided to prevent loss of function if the primary closure fails. The motor has antifriction bearings, each of which is provided with its own oil supply.

The total oil volume is six gallons. The motor is cooled by helium-to-water heat exchangers within the motor frame. The water is supplied by the plant cooling system which is Class 1. The motor cavity is depressured through the center of the shaft to follow the primary system pressure. The bearing oil module is not permanently connected to the motor but is actually a detachable service cart for all circulators. Its design incorporates an interlock to control the inventory of oil within the motor during oil changes (on a 2 year schedule) to prevent spills into the primary helium system.

Mr. Kapich's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. C. Forkel - The oil pump, which is integral with the motor shaft at each antifriction bearing, discharges the oil to its sump via a pipe not shown on the viewgraph.

2. C. Forkel - The plant cooling system water is at a pressure of approximately 40 psig, so helium leaks into the water - not vice-versa.

3. F. Swart - The buffer helium supplied to the motor doesn't return to the primary system saturated with oil. It is discharged from the motor to an oil adsorber and thence to the helium purification unit for clean up and recycle.

4. V. Scotti - The vapor pressure of the lubricating oil is unknown.

5. P. Kasten - The British reactors have sleeve bearings that are oil lubricated from an external supply with a 2-m^3 sump. Their experience from this system has been bad.

6. K. Van Howe - The oil is cooled by a water coil in the bottom of each sump.

7. V. Scotti - The duty cycle on the motor is 5,000 hrs at maximum speed and DBA. With no DBA it is infinite on the bearings. The motor will be continuously rotated at low speed to prevent brinelling of bearings.

8. V. Scotti - Loss of oil to the flowing buffer helium is limited by the contact surface being only about 1 in^2.

9. P. Kasten - The loss of oil in two years of operation at full speed is expected to be one gallon.

10. C. Forkel - Buffer helium is supplied through an axial hole from the top of the shaft to radial holes at the two bearings. The axial hole is blind at the bottom so that it does not communicate with the primary system.

11. L. Welshans - The maximum-to-need power ratio of three makes it possible to reduce the size of the power supply. Reducing the size of the motor would not result in much savings. Also, a smaller motor would not reduce the size of the cavity in the PCRV because its size is dictated by the helium flow passage.

12. L. Welshans - The motor is designed to resist helium temperatures of 1700°F by means of insulation on the bottom of the motor and cooling coils in the bearing cavity. The hot soak requirement is a temperature of 750°F for an indefinite duration. The cooling system is necessary because the motor itself is designed for only 107°C.

13. K. Van Howe - The ISI will consist of:
    a) Periodic start at 10% speed while the plant is under full power

    b) Monitoring for high and low oil level in the sump

    c) Monitoring for helium in the cooling water

    d) Exercising the ALIV with the high pressure helium jet

    e) Monitoring the double closure interspace for loss of pressure

    f) A 10% speed in reverse alarming for operator action.

VII. AUXILIARY CIRCULATOR DESIGN AND TECHNOLOGY PLANS

VII.a. The overview network and program costs were presented by Michael K. Nichols. The auxiliary circulator program follows the main circulator program. There has not been much recent work on the auxiliary circulator but the configuration has been adopted from the Delmarva design.

The work of tailoring the design to the specific requirements for the HTGR-SC/C is just getting underway. The results of a number of component tests will be input to the design of the prototype which will be tested in the GA facility. Because of the safety requirements, the tests will become a qualification for licensing before the commitment to the production hardware. The overall program cost is smaller than that for the main helium circulator. The viewgraph titled, "HTGR-SC/C Design Project No. 6654 Rev. B, Dtd. 10/30/81" is in error. The large spike should be removed. It includes about $3.6M of production hardware which does not belong in the design costs. This correction will reduce the total cost to about one half. The costs assume the use of the main helium circulator test facility.

VII.b. The design data needs and technology plan were presented by Michael K. Nichols.

A full size lower bearing and oil foaming test with helium has been completed. Radiation tests on the lubricating oil have resulted in the 2-year oil replacement requirement. At the end of the 2-year period enough oil must remain in the sump for a DBDA. The oil level is indicated in the control room.

The motor cooling test is a mockup of the motor run in air. It is needed because the motor manufacturers have no pressure drop data of the cooling gas passages. The aerodynamic test will be a scale model test in air. The oil irradiation test will be performed on oils developed since the last test to determine if a better oil is available. The impeller blade vibration test will be for the purpose of determining the natural frequency of the blades.

The qualification test will be with a full size prototype in the actual reactor environment and in accordance with 10 CFR 50. The planned Delmarva test was to include an "aged stator" which was actually baked to an end of life condition per IEEE. This is still the plan for the SC/C auxiliary circulator. The seismic test will consist of placing the circulator and motor on a shaker table and demonstrating its ability to operate during a seismic event.

Mr. Nichols' response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - If the oversize Delmarva design were not available, essentially the same amount of testing, not more testing, would be required because the tests are just now being started. The only exception would be the bearing test which has been completed. A smaller, higher speed machine may require a repeat of this test. The capacity and dependability of the circulator is of prime importance; the efficiency is of very little concern. The size of the cavity for this motor is dictated by the size of the impeller; not the motor size.

2. K. Van Howe - Windmilling of the circulator is not a problem. It is desirable because it will prevent brinelling of the bearings.

3. Unknown - The prototype test facility will be in the same building as the main circulator test facility.

4. L. Welshans - The seismic test will be performed at Wyle Laboratories or a similar facility capable of shaking a mass of about 30,000 lbs.

5. K. Van Howe - The seismic test of the auxiliary circulator will not include the ALIV. It will be qualified analytically or shake tested separately.

6. P. Kasten - There is no problem in testing both main and auxiliary circulators in the same facility since the auxiliary circulator follows the main circulator schedule. This will allow the use of the same personnel for both tests.

7. K. Van Howe - The speed of the circulator windmilling in reverse will be determined in 1/3-scale air flow test. The torque with a locked rotor will also be measured. The design intent is not to burst the rotor at this condition.

8. C. Forkel - The windmilling speed will be determined analytically and verified on the 1/3-scale air flow test.

VIII. CONTROL AND ELECTRICAL SYSTEMS FOR CACS

James Vavrina presented the portion of the handouts related to the control and electrical system for the CACS. The system includes the variable frequency power supply, the automatic sequencer, the core auxiliary heat exchanger (CAHE) water temperature outlet controller, and the safety related display instrumentation (SRDI) which monitors the overall system performance.

Upon command from the plant protection system, the automatic sequencer assures that the CACS pressurizer is up, the water pumps are running, and the air blast heat exchanger (ABHE) fans are on. The auxiliary circulators are then controlled by the CAHE water outlet temperature. The maximum time for the CACS to go from standby to full cooling is eight minutes. The system would require five minutes to full cooling with on-site power; however, if on-site power were lost at the end of the five minutes, an additional three minutes would be required to bring on backup diesel power. This would be the worst case.

The variable frequency power supply is similar to that used for the main circulators except for being of much lower power. The protection for the drive motor is conventional. The NRC requirements for the system are reflected in the referenced IEEE standards.

Mr. Vavrina's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. F. Swart - The motor controller output voltage and frequency are both controlled so that their relationship remains constant.

2. K. Van Howe - The ABHE operation is initiated by the sequencer. Its heat transfer is controlled by automatic louvers based on the outside air temperature and air discharge temperature.

3. L. Welshans - The plant condition that causes the system to start is loss of cooling. Consideration has also been given to loss of feed water and loss of off-site power.

4. P. Kasten - The controls and sensors for the system are off-the-shelf except for qualification.

IX. CONTROL AND ELECTRICAL DESIGN TECHNOLOGY PLANS

James Vavrina presented the portion of the handouts related to the CACS control and electrical design technology plans. The primary design data needs are verification by test of the circulator performance and the functioning of its labyrinth seals, the compatibility of the motor and its controller, and proper interaction of the CACS controls with their interfacing control systems.

This concludes the minutes for the presentation of the auxiliary circulator baseline design review and Part A.

HTGK
DESIGN REVIEW
SESSION II C
12/9/81

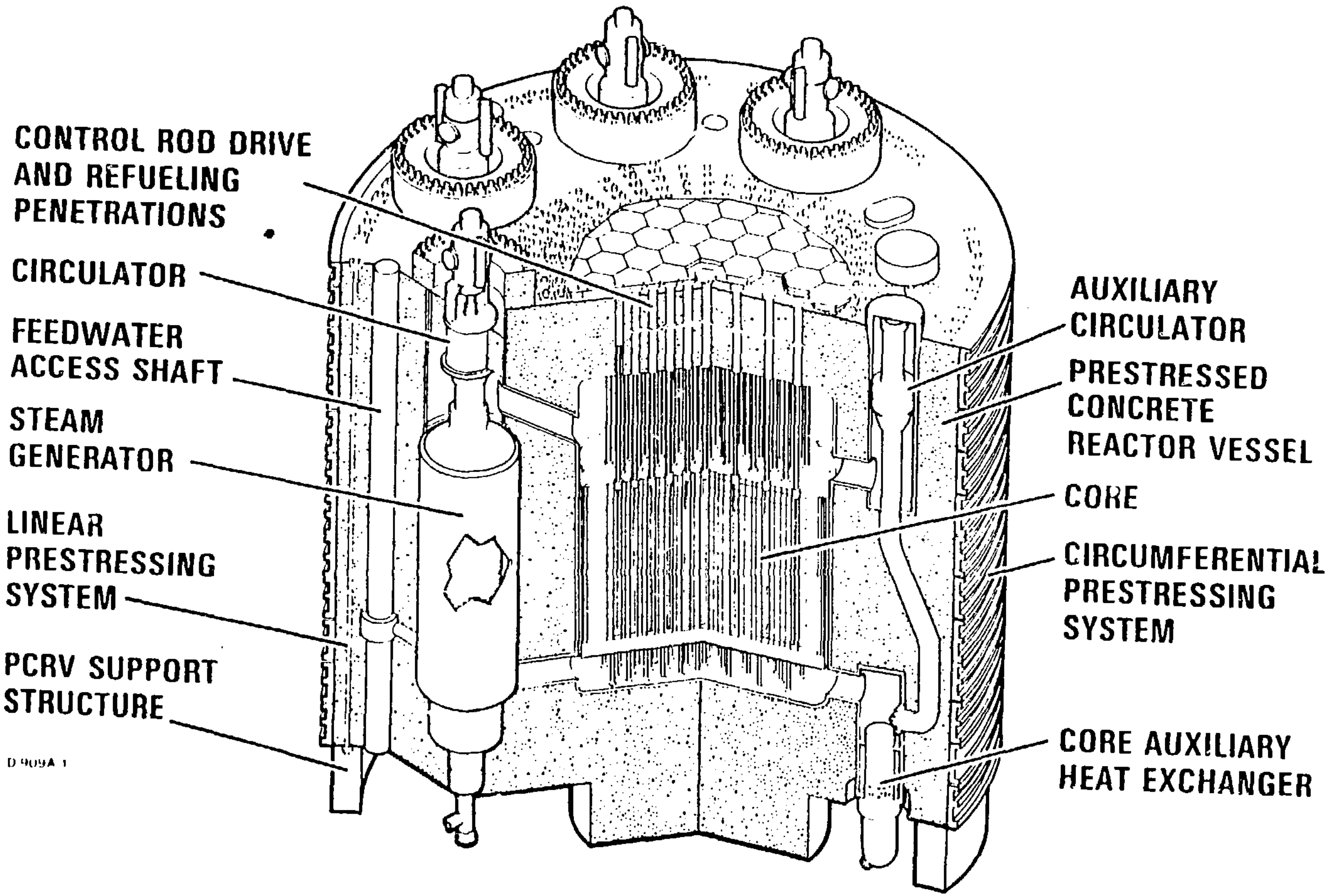
NAME	ORGANIZATION
MIKE NICHOLS	GA
JOHN KRASE	GA
DAVE KAPICH	GA
Fred Swart	GCRA
CHARLIE BOLAND	GA
Vincent S. Scotti	CE
CLIVE DUPEN	C-E
PAUL KASTEN	ORNL
STAN BROWN	GAC
L M WELSHOUS	DOE
A.J. Goodjohn	GAC
JOHN PICCOLO	EG&G
JOHN ANDERSEN	GA
DON GIEGLER	GA
CARMELO RODRIGUEZ	GA
K.R. VAN HOWE	SMSC
Robert F. Stearns	Bechtel
R. A. Evans	GCRA
MERWIN BROWN	ARIZ. P&S SER. Co.
CURT E. FORKEL	EG&G

HTGR MAIN CIRCULATOR

GENERAL ATOMIC COMPANY

GENERAL ATOMIC

HTGR NUCLEAR STEAM SYSTEM



A27

GENERAL ATOMIC

MAIN CIRCULATOR REQUIREMENTS

A28

A. SAFETY

1. FUNCTION IS NON-SAFETY CLASSIFIED.
2. PRIMARY COOLANT BOUNDARIES ARE SAFETY CLASSIFIED.
3. SEISMIC AND ROTOR FAILURE: A) NOT TO DAMAGE OTHER COMPONENTS, B) NOT TO CAUSE BREACH OF PRIMARY BOUNDARY.

B. FUNCTIONAL

1. CIRCULATE AND CONTROL THE PRIMARY COOLANT FLOW.
2. SURGE MARGIN TO BE AT LEAST 20% OF THE FLOW RATE AT THE WORST COMBINATION OF SYSTEM MARGINS.
3. MINIUMUM AND MAXIMUM CONTROLLABLE SPEED TO SATISFY PLANT TRANSIENT SPECIFICATION.
4. PREVENT THE LUBRICANT ENTERING THE PRIMARY COOLANT AND VICE VERSA.

GENERAL ATOMIC

MAIN LOOP ISOLATION VALVE REQUIREMENTS

A29

A. SAFETY

1. FUNCTION – SAFETY CLASSIFICATION.
2. CLOSED EXCEPT WHEN MAIN CIRCULATOR OPERATING.
3. FLOW ACTUATION WITH CLOSURE ASSIST AND POSITION INDICATION.

B. FUNCTIONAL

1. PREVENT THE BACK FLOW OF PRIMARY COOLANT.
2. ACTUATION TIME TO SATISFY PLANT TRANSIENT SPECIFICATION.
3. TO BE REMOVABLE THROUGH THE CIRCULATOR PENETRATION.

MAJOR DESIGN CONSIDERATIONS

A. HIGH AVAILABILITY

- SIMPLIFIED AND HARDENED SHAFT SEAL SYSTEM.
- SEPARATION OF CIRCULATOR DRIVE FROM NSS.
- RELOCATION OF CRITICAL COMPONENTS FROM WITHIN THE CIRCULATOR TO OUTSIDE.
- RUGGED AND FUNCTIONAL MECHANICAL DESIGN.
- MINIMUM MAINTENANCE REQUIREMENTS.
- EASY REMOVAL AND INSTALLATION.
- USE PROVEN TECHNOLOGIES.

B. GOOD OPERABILITY

- MINIMUM CIRCULATOR INTERACTION WITH OTHER PLANT SYSTEMS.
- SIMPLE AND ACCURATE CONTROLS.

C. PRENUCLEAR TESTING

- ABILITY FOR FULL POWER ALL LOOPS TESTING.
- ALSO LOOP INTERACTION WITH FLOW MISMATCH, LOOP TRIP, RESTART, ETC.

D. PERFORMANCE

- HIGH PLANT CAPITAL COST JUSTIFIES REFINED AERODYNAMIC DESIGN.

MAIN CIRCULATOR DESIGN BASIS
PERFORMANCE REQUIREMENTS AT FULL LOAD

GENERAL ATOMIC

INLET PRESSURE	1027.1
PRESSURE RISE	22.9 PSI
INLET TEMPERATURE	606°F
MASS FLOW RATE	637.1 LB/SEC

GENERAL ATOMIC

MAIN CIRCULATOR DESIGN BASIS PERFORMANCE REQUIREMENTS AT FULL LOAD (CONT)

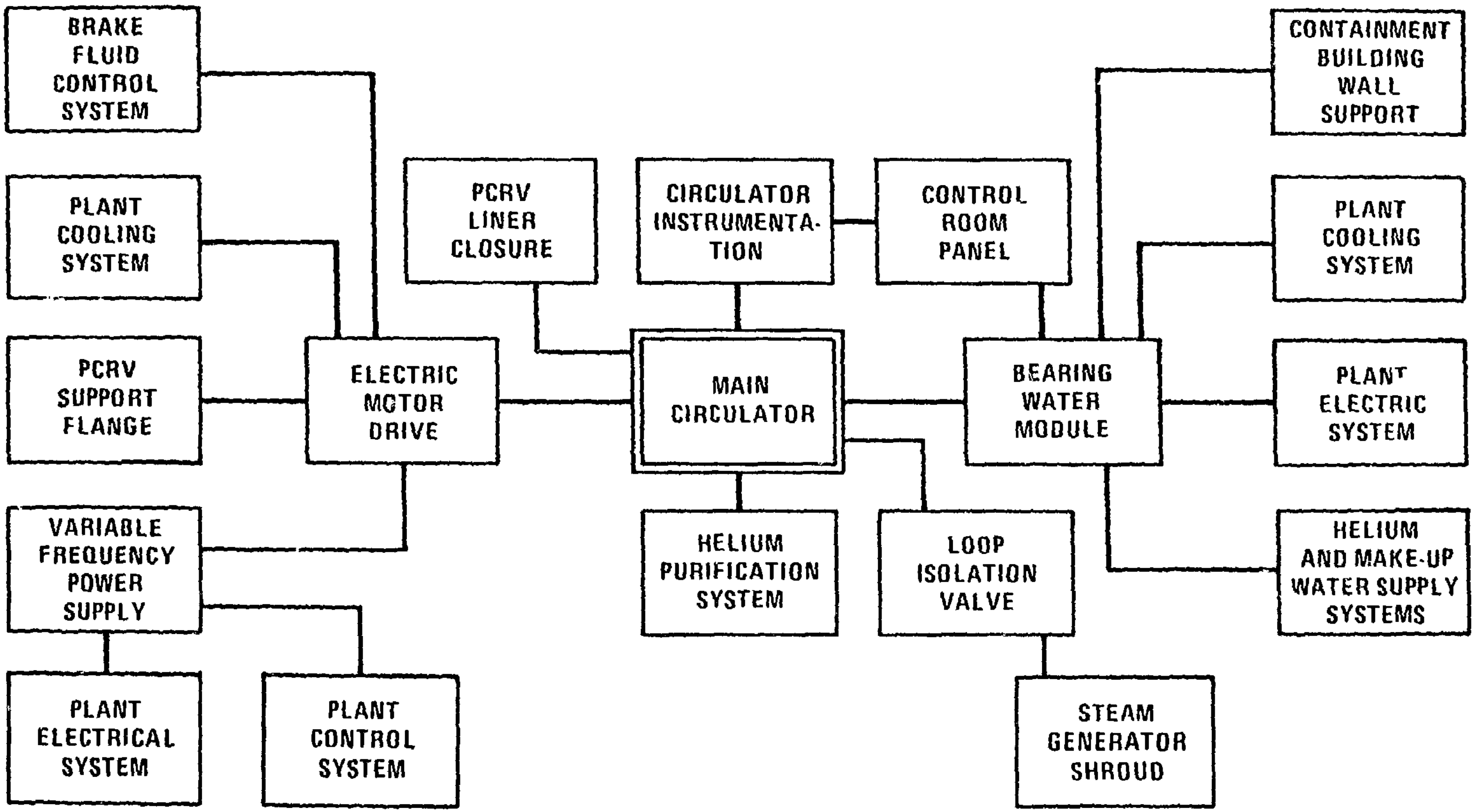
A32

CIRCULATOR PRINCIPAL CHARACTERISTICS	
SHAFT POWER	11,300 KW
ROTATING SPEED	2360 RPM
IMPELLER/DIA.	RADIAL/72.0 IN.
BEARINGS	WATER LUBRICATED, HYBRID, ULTRA HIGH STIFFNESS
FIRST CRITICAL SPEED	4300 RPM
DRIVE MOTOR PRINCIPAL CHARACTERISTICS	
TYPE	SOLID ROTOR, SYNCHRONOUS
SPEED CONTROL	SOLID STATE, SELF COMMUTATED CONVERTER
BEARINGS	OIL LUBRICATED, TILTING PAD, TWO RADIAL PLUS SINGLE THRUST

F-596(R)

GENERAL ATOMIC

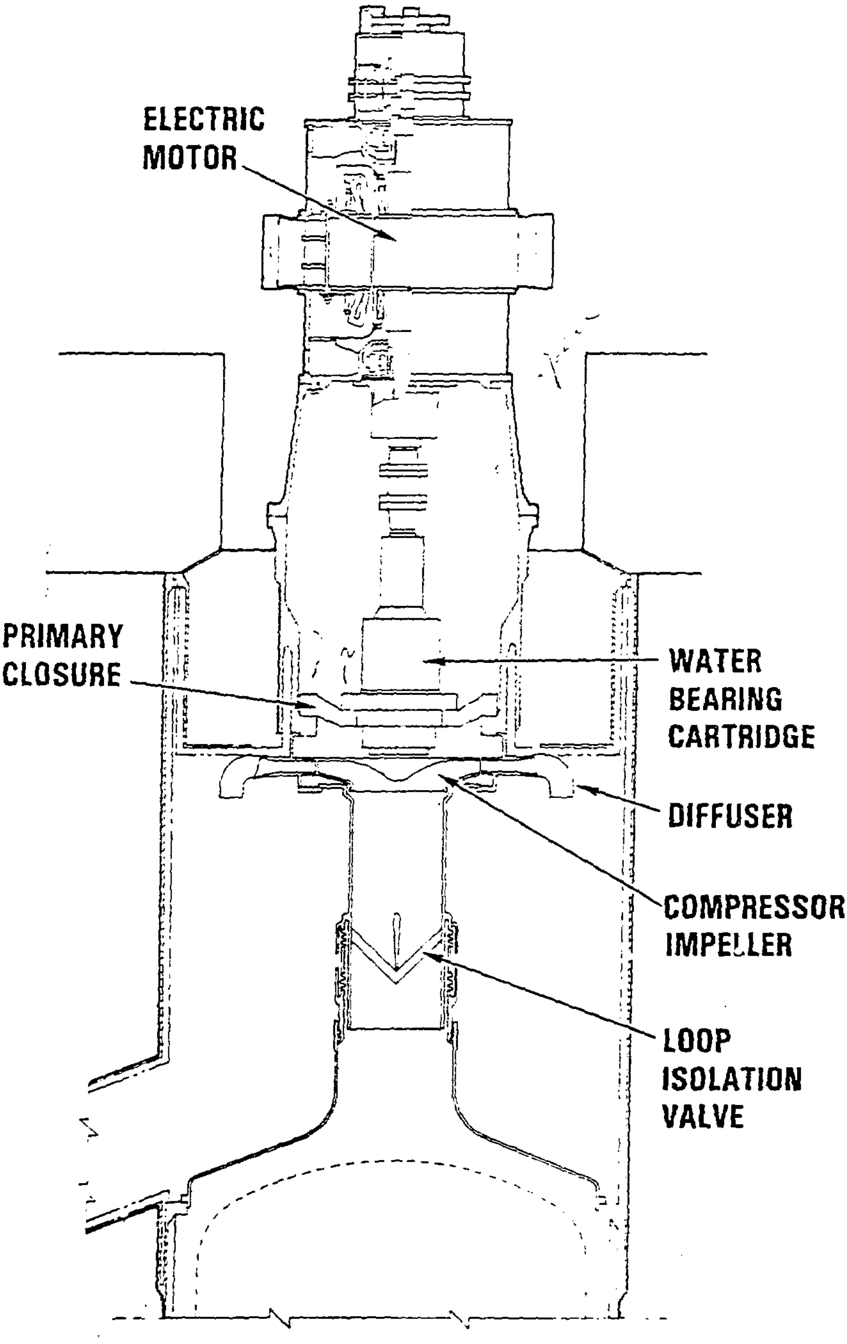
MAIN CIRCULATOR INTERFACES



F-890(2)

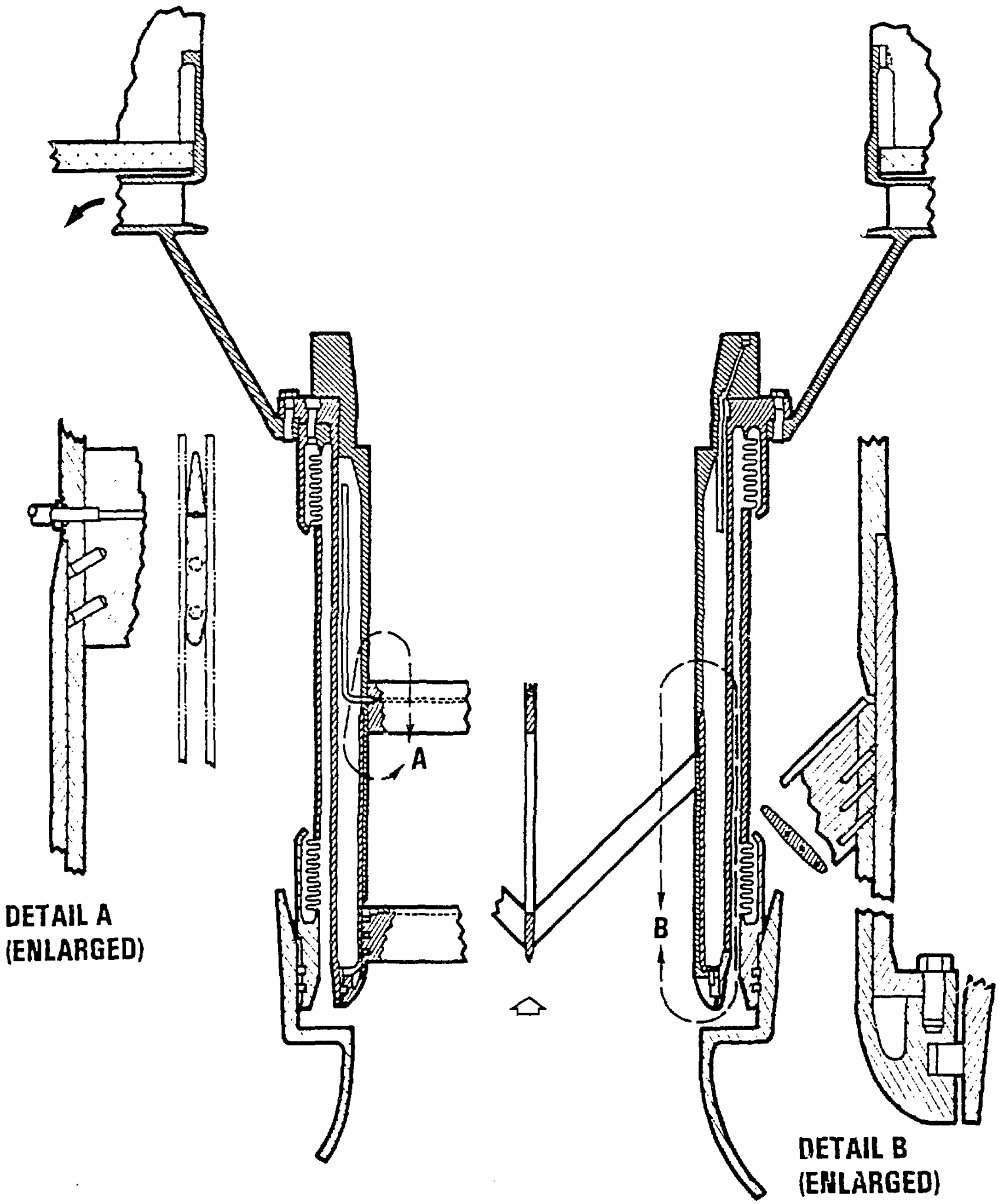
HTGR-SC/C MAIN HELIUM CIRCULATOR AND DRIVE

GENERAL ATOMIC



F-831(1)

LOOP ISOLATION VALVE ASSEMBLY



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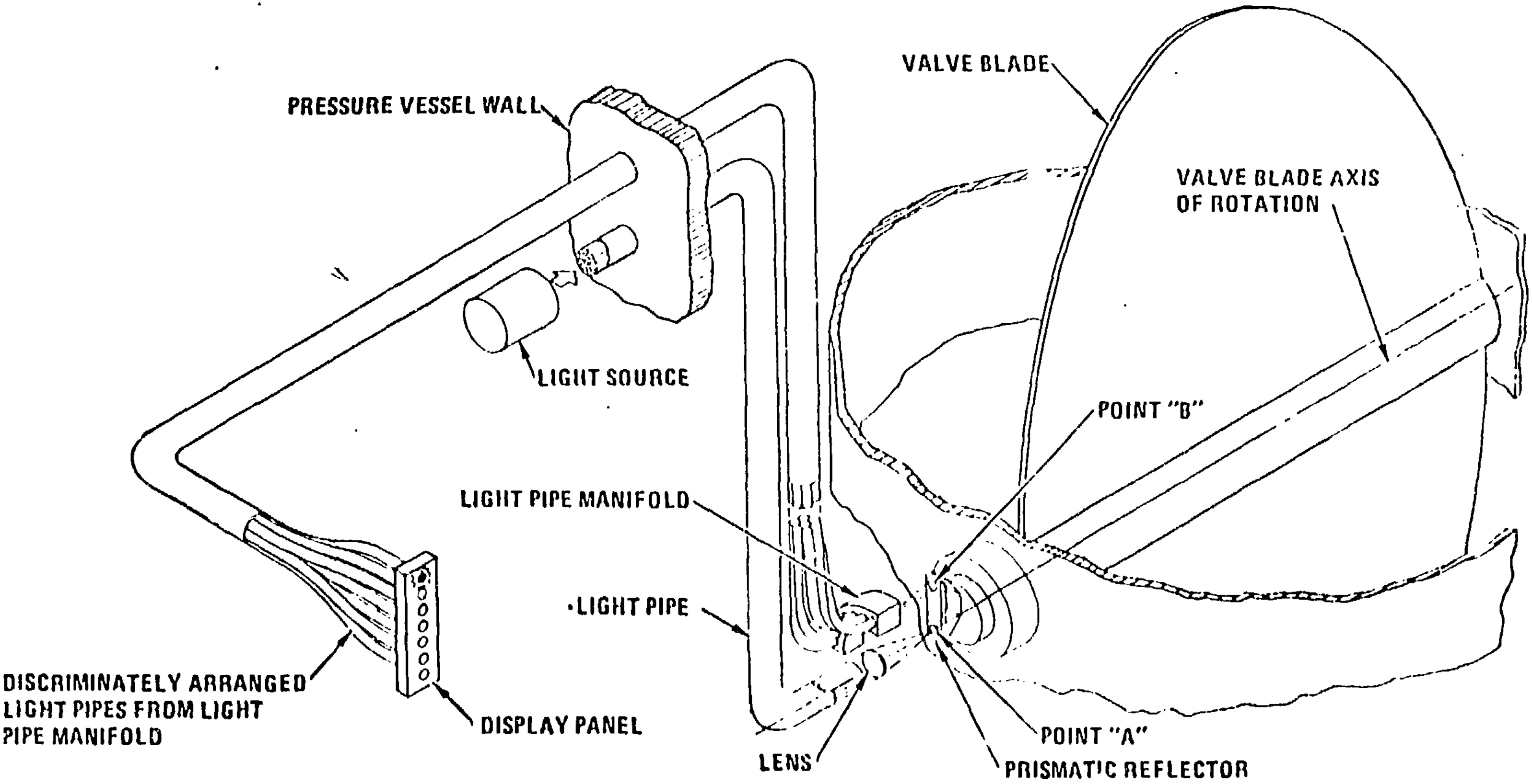
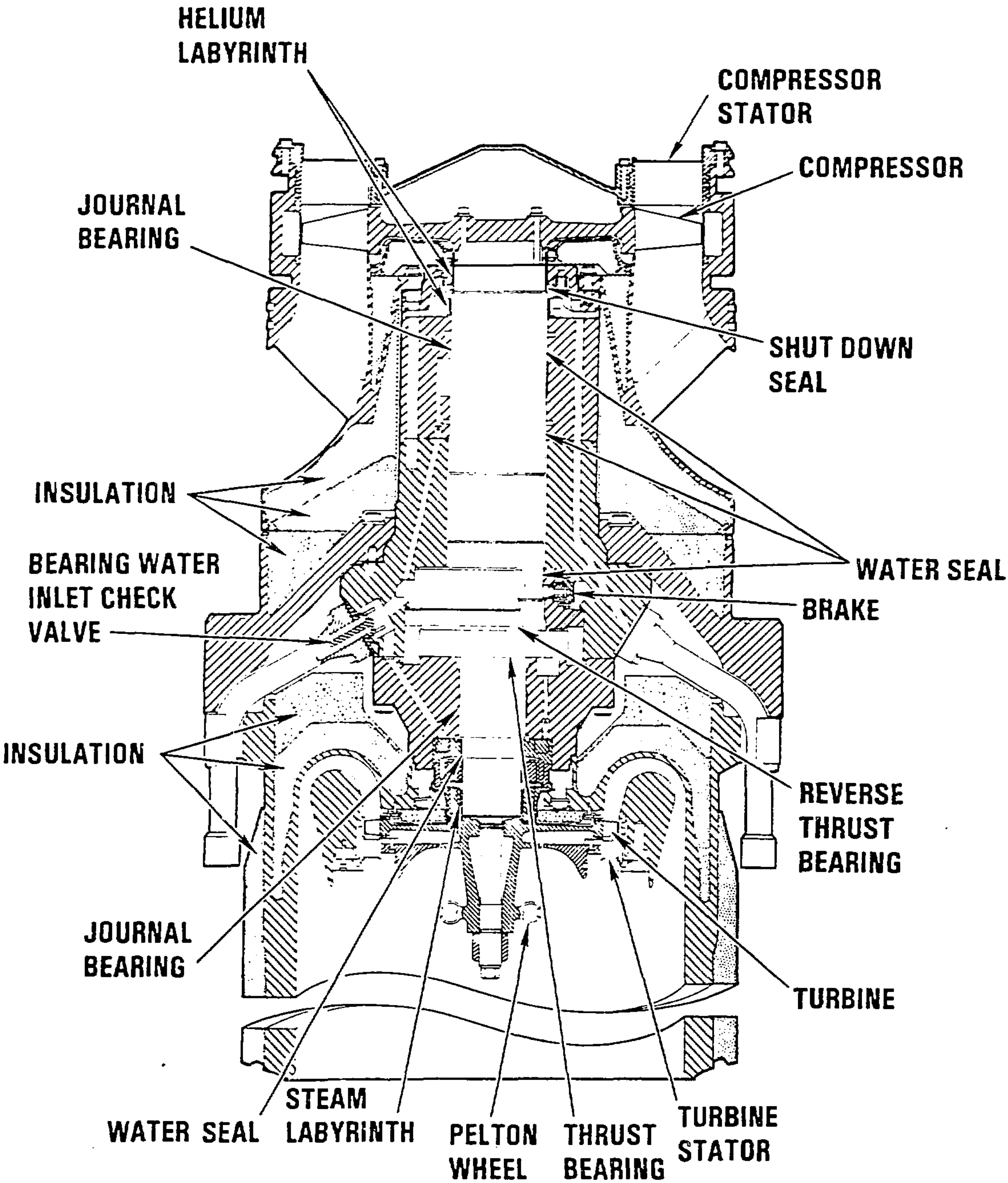
RMB 7025

FIBER OPTIC VALVE POSITION INDICATOR



FSV HELIUM CIRCULATOR ASSEMBLY

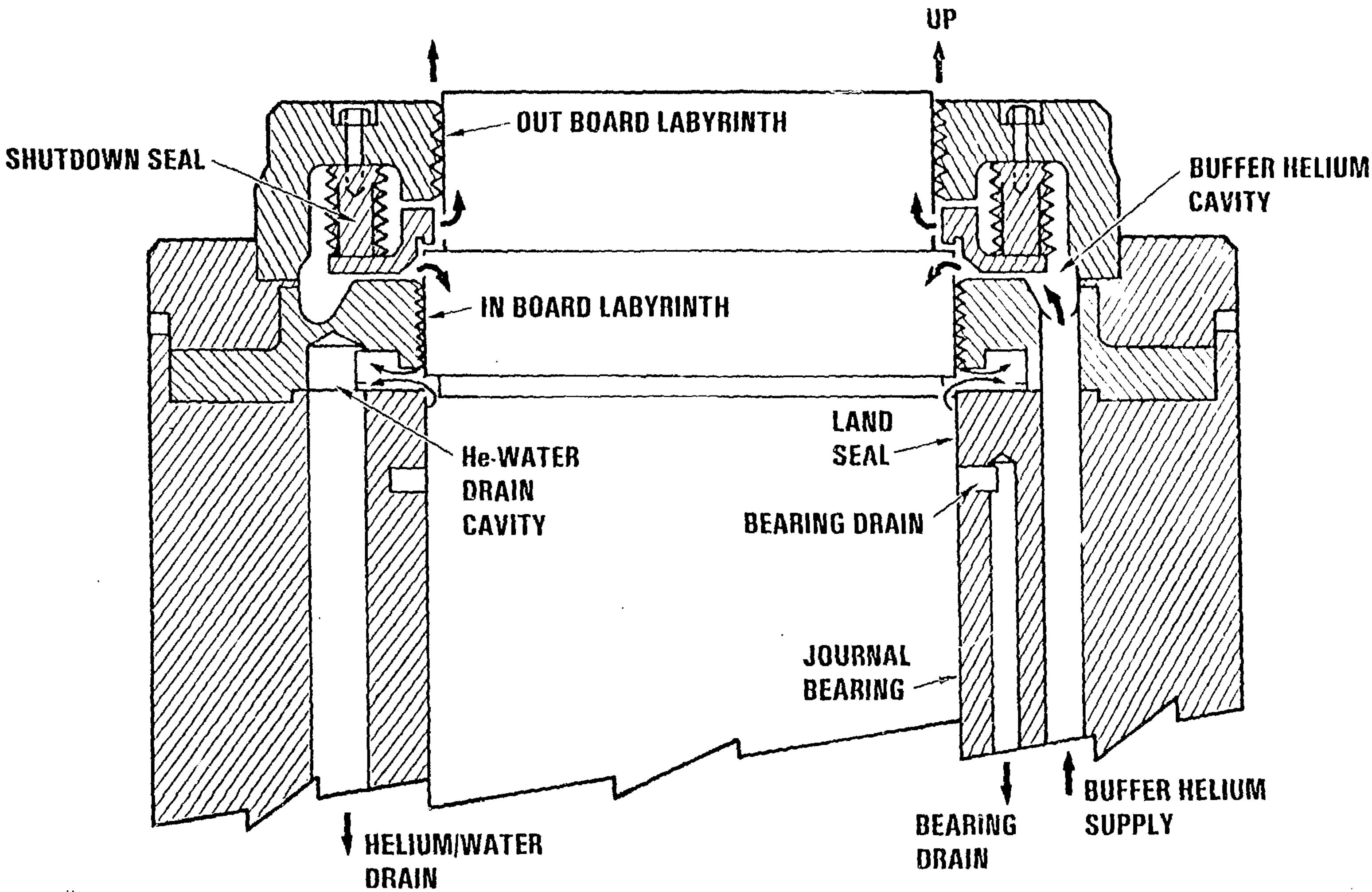
GENERAL ATOMIC



F-890(4)

FORT ST. VRAIN – HELIUM/WATER SEAL

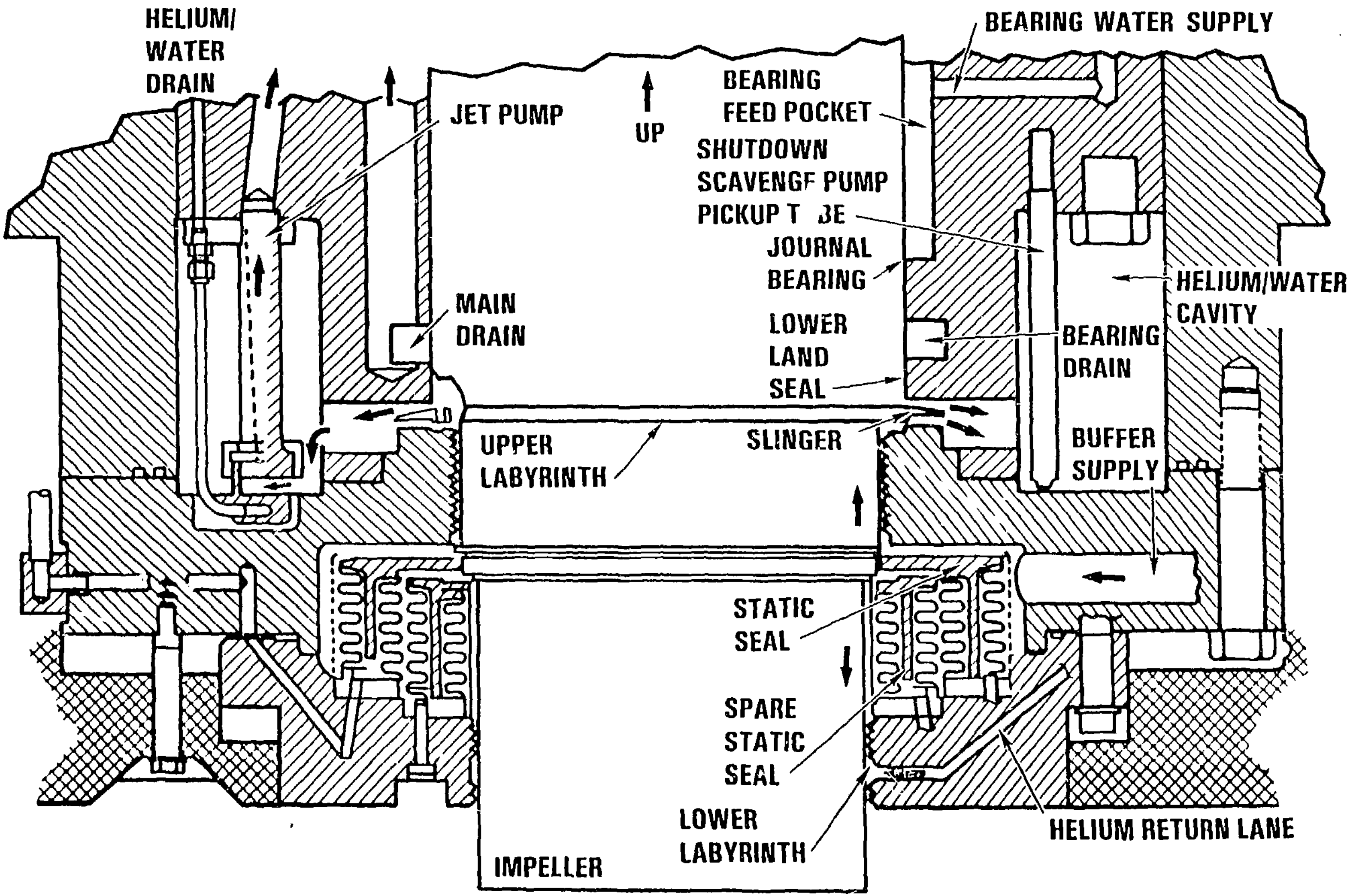
GENERAL ATOMIC



A38

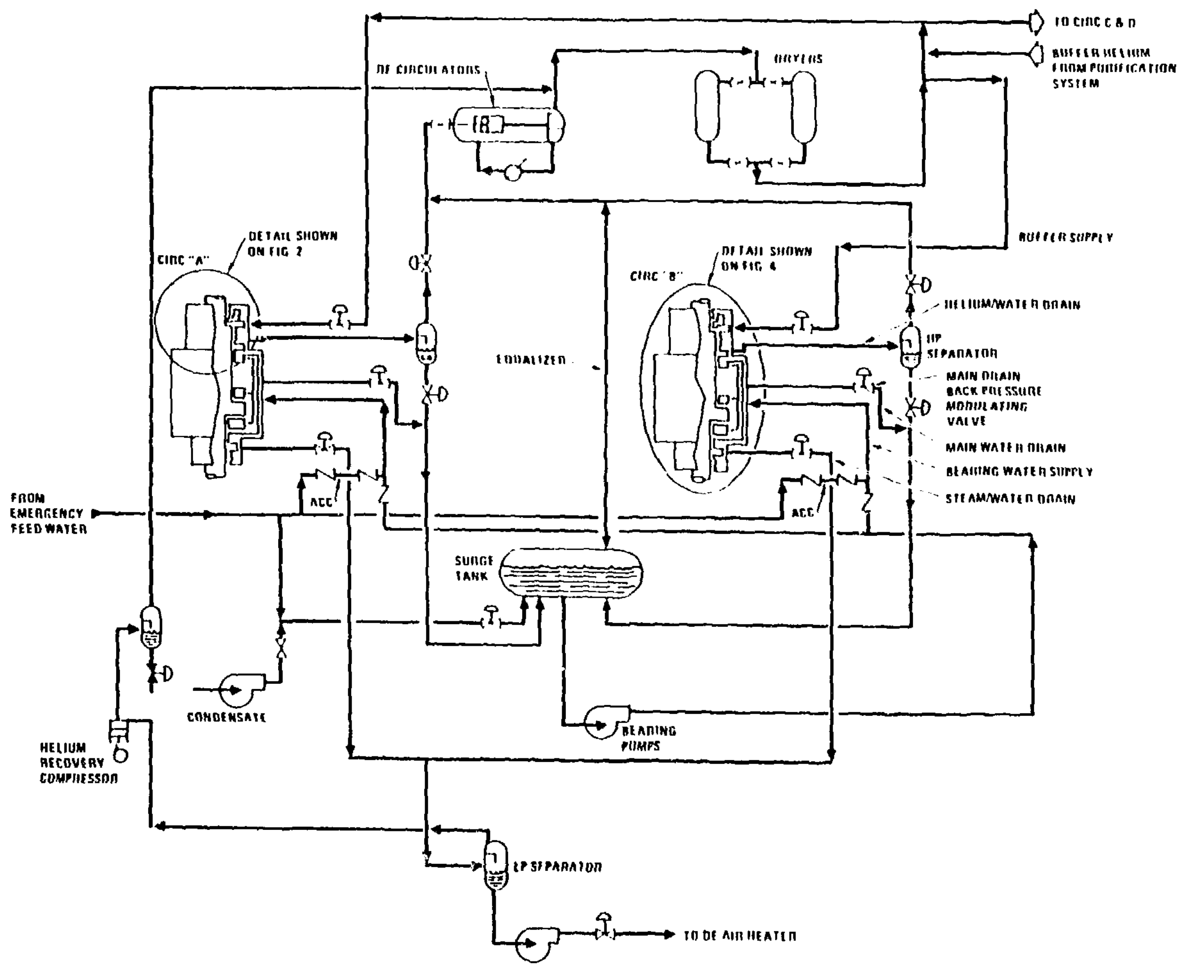
GENERAL ATOMIC

HELIUM/WATER SEAL AND SCAVENGE SYSTEM



A39

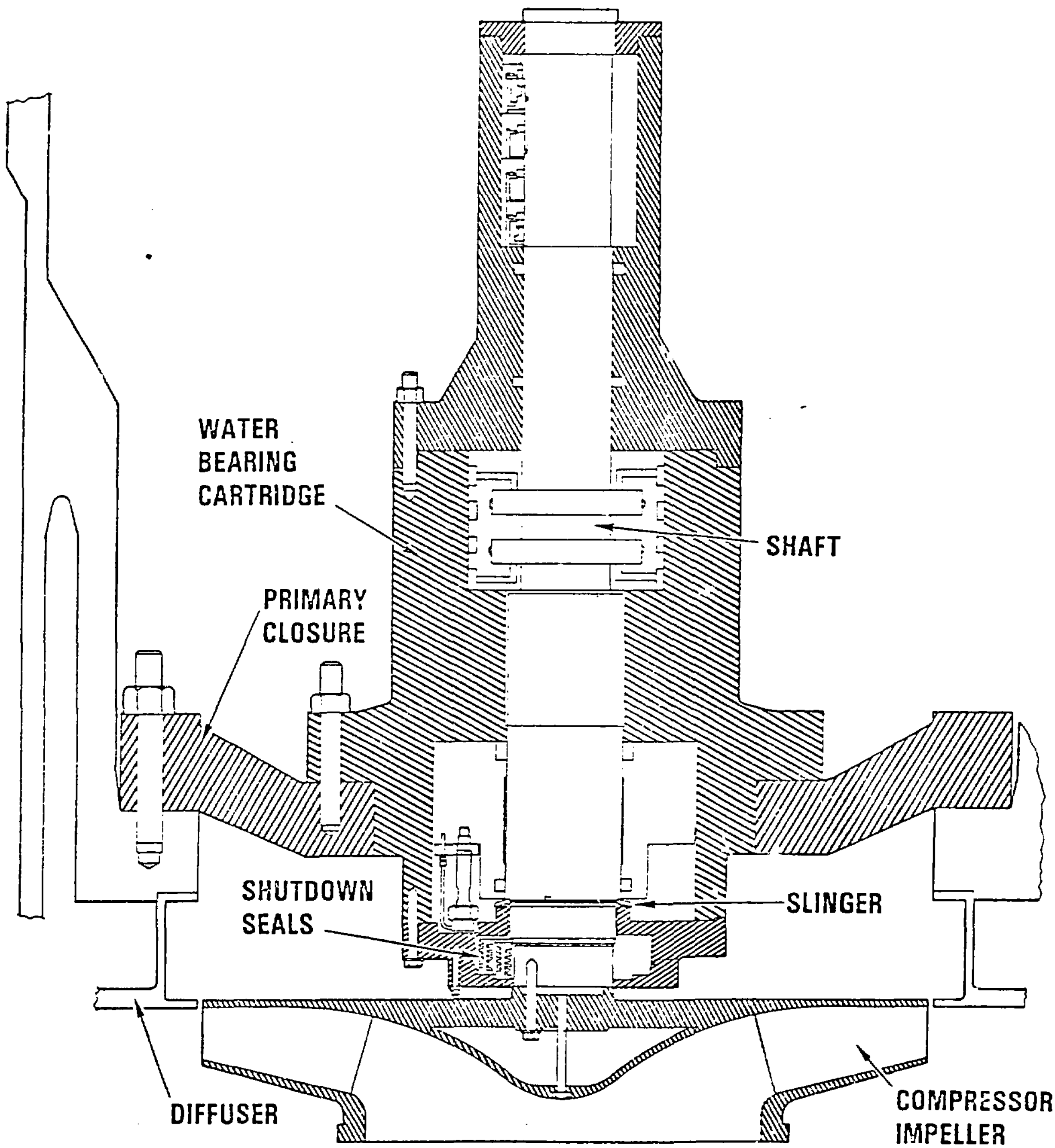
FORT ST. VRAIN SERVICE SYSTEM



F-602

HTGR-SC/C MAIN HELIUM CIRCULATOR AND DRIVE

GENERAL ATOMIC



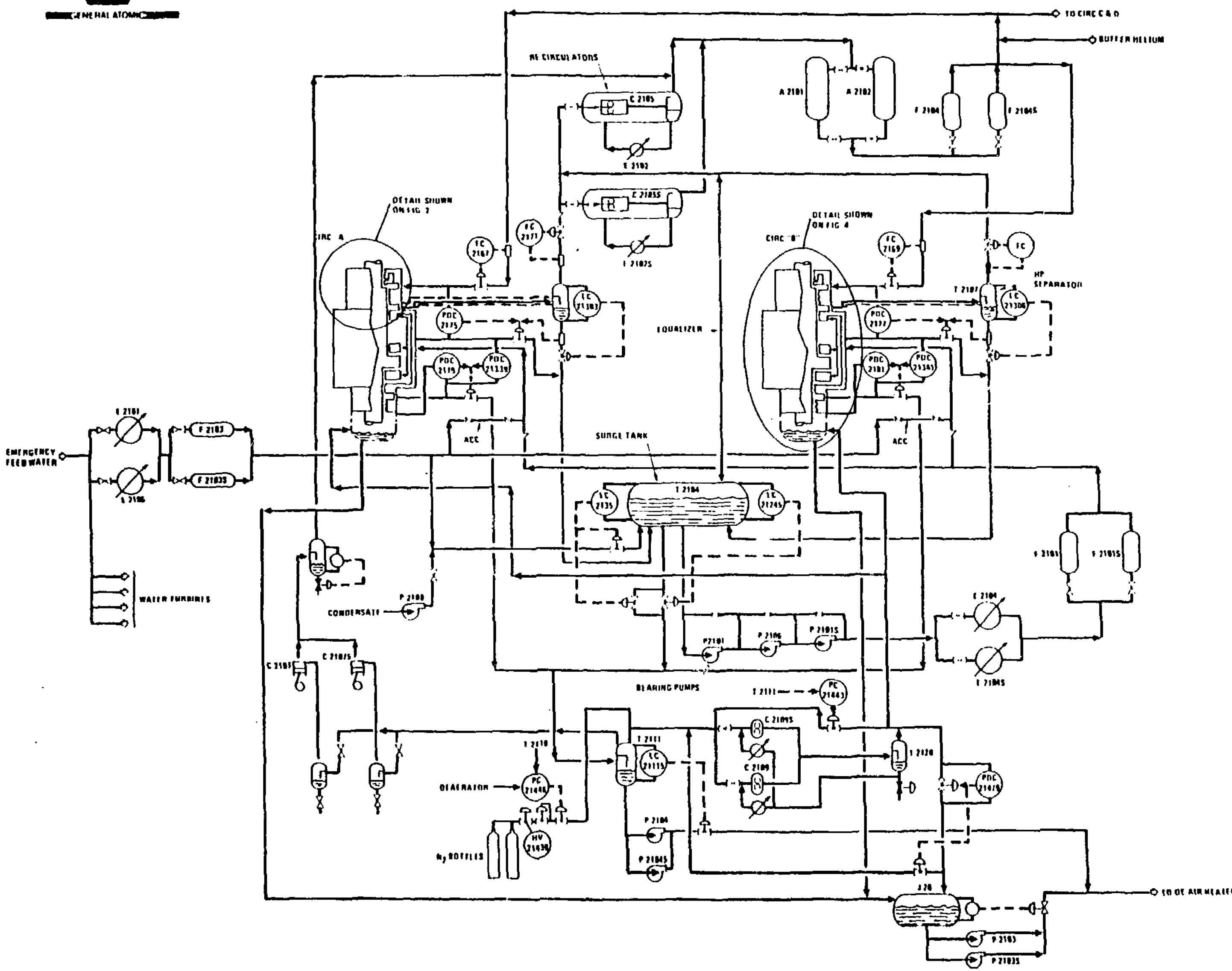
F-831(3)

GENERAL ATOMIC

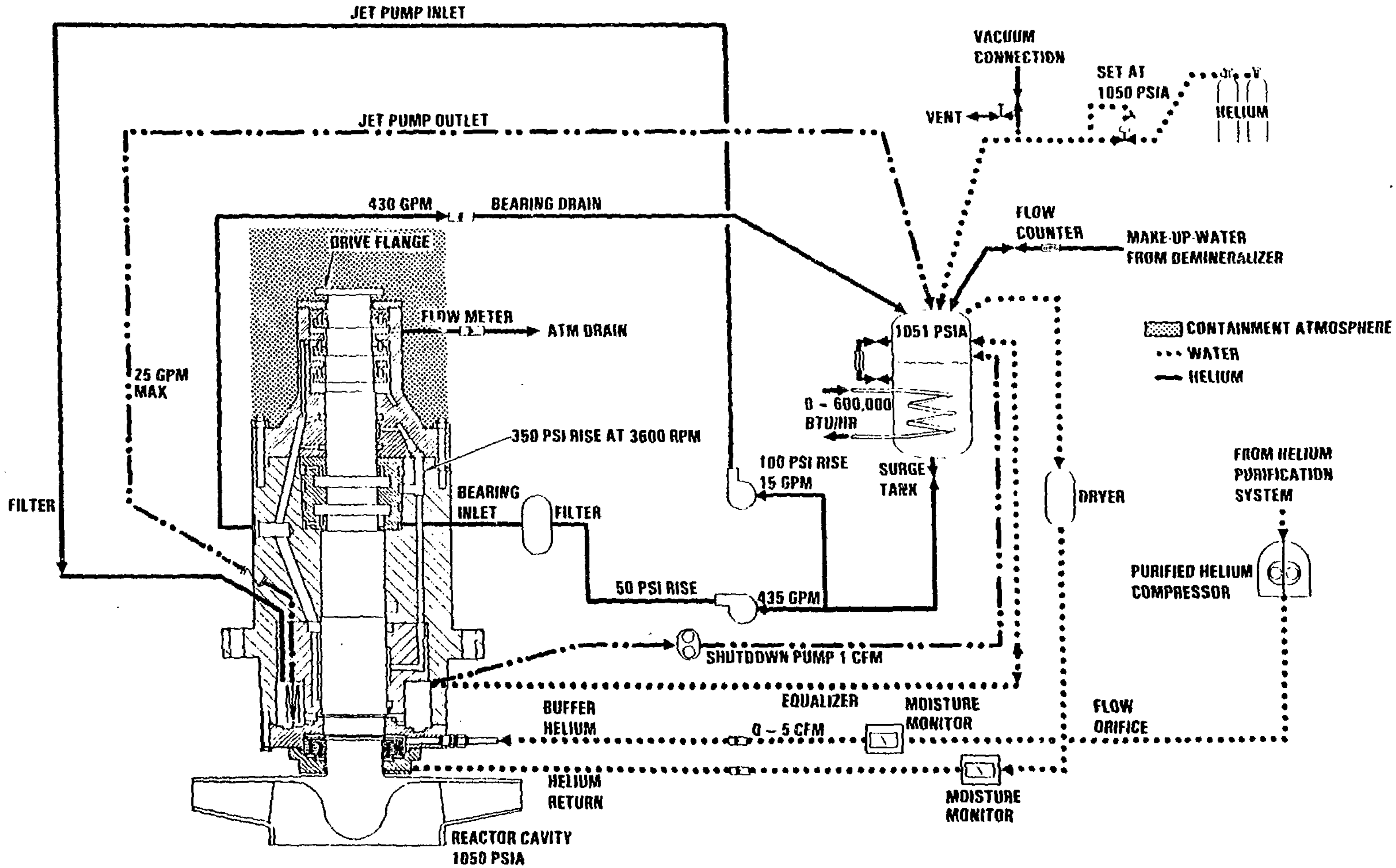
PLANT	MAIN CIRCULATOR SERVICE SYSTEM
FSV	• CLASS I/SAFE SHUTDOWN COOLING E.G., BACK BEARING WATER & MAKE-UP; INSTALLED SPARES PPS • TWO CIRCULATORS PER SERVICE SYSTEM • BUFFER HELIUM INTERNALLY RECIRCULATED • LOW PRESSURE HELIUM RECOVERY
PE/DPL	• NO SAFE SHUTDOWN COOLING REQUIRED • BACKUP BEARING WATER FOR AVAILABILITY ONLY • ONE SERVICE SYSTEM PER CIRCULATOR EXCEPT: BUFFER HELIUM DRYERS BACKUP AND MAKEUP BEARING WATER LOW PRESSURE HELIUM RECOVERY • BUFFER HELIUM RECIRCULATED BY He PURIFICATIONS SYS. • JET PUMP DRAIN SCAVENGING
REF 2240 MW(t) HTGR-SC/C	• SIMPLER SERVICE SYSTEM, CONTROLS ONLY FOR MAKE-UP • BEARING WATER PUMP INTEGRAL WITH CIRCULATOR SHAFT • NO BACKUP BEARING WATER • NO SHUTDOWN ACCUMULATORS • NO LOW PRESSURE HELIUM RECOVERY • NO SHARED EQUIPMENT BETWEEN CIRCULATORS • FEWER SERVICE SYSTEM TRANSIENTS • LESS PLANT AND CONTAINMENT BLDG. SPACE

F-875(2)

FSV SERVICE SYSTEM



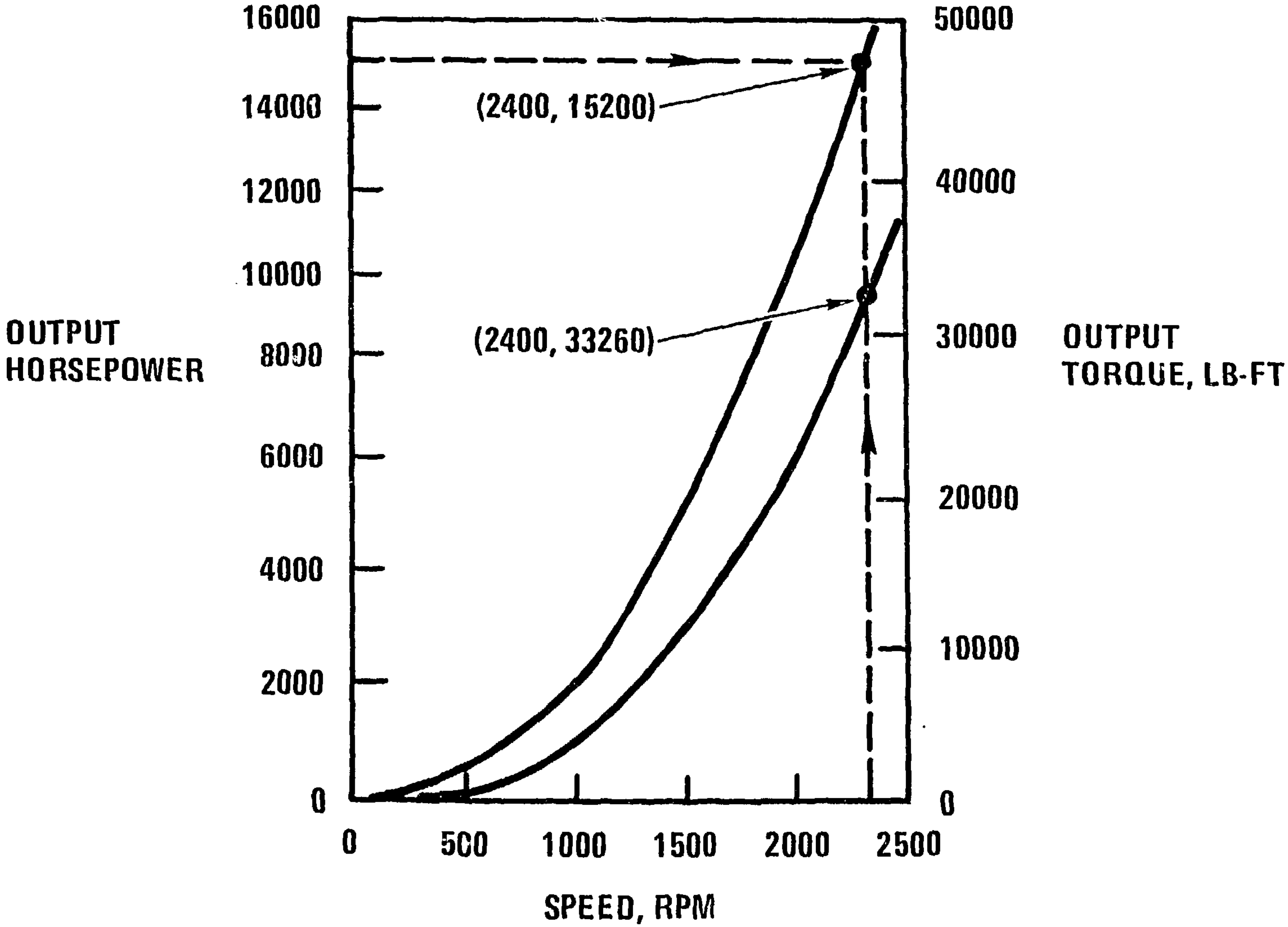
HTGR-SC/C MAIN CIRCULATOR – BEARING AND SERVICE SYSTEM



F-875(3)

A45

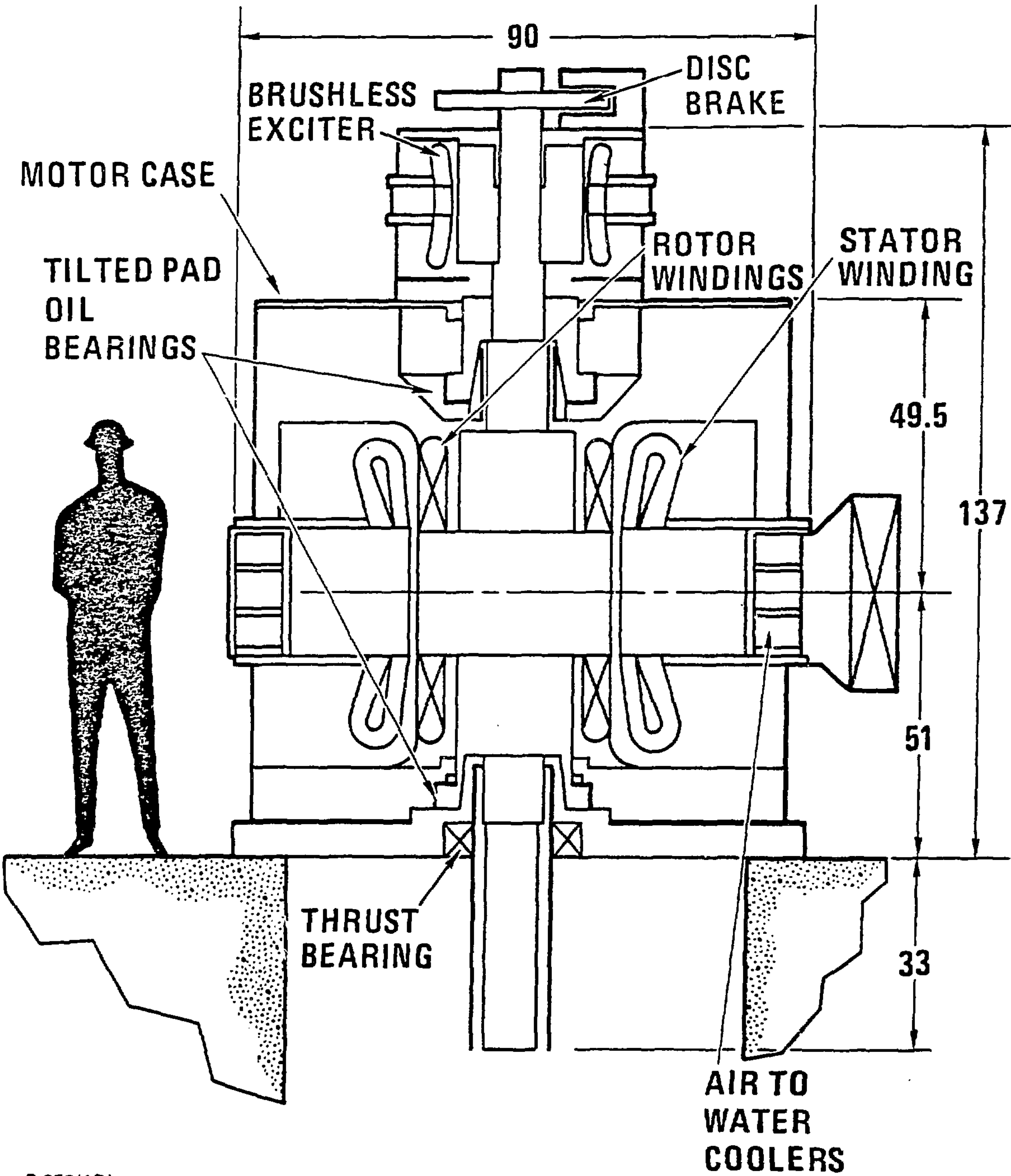
OUTPUT HP AND TORQUE VS. SPEED
VARIABLE SPEED CIRCULATOR DRIVE MOTOR FOR HTGR LOOP



A46

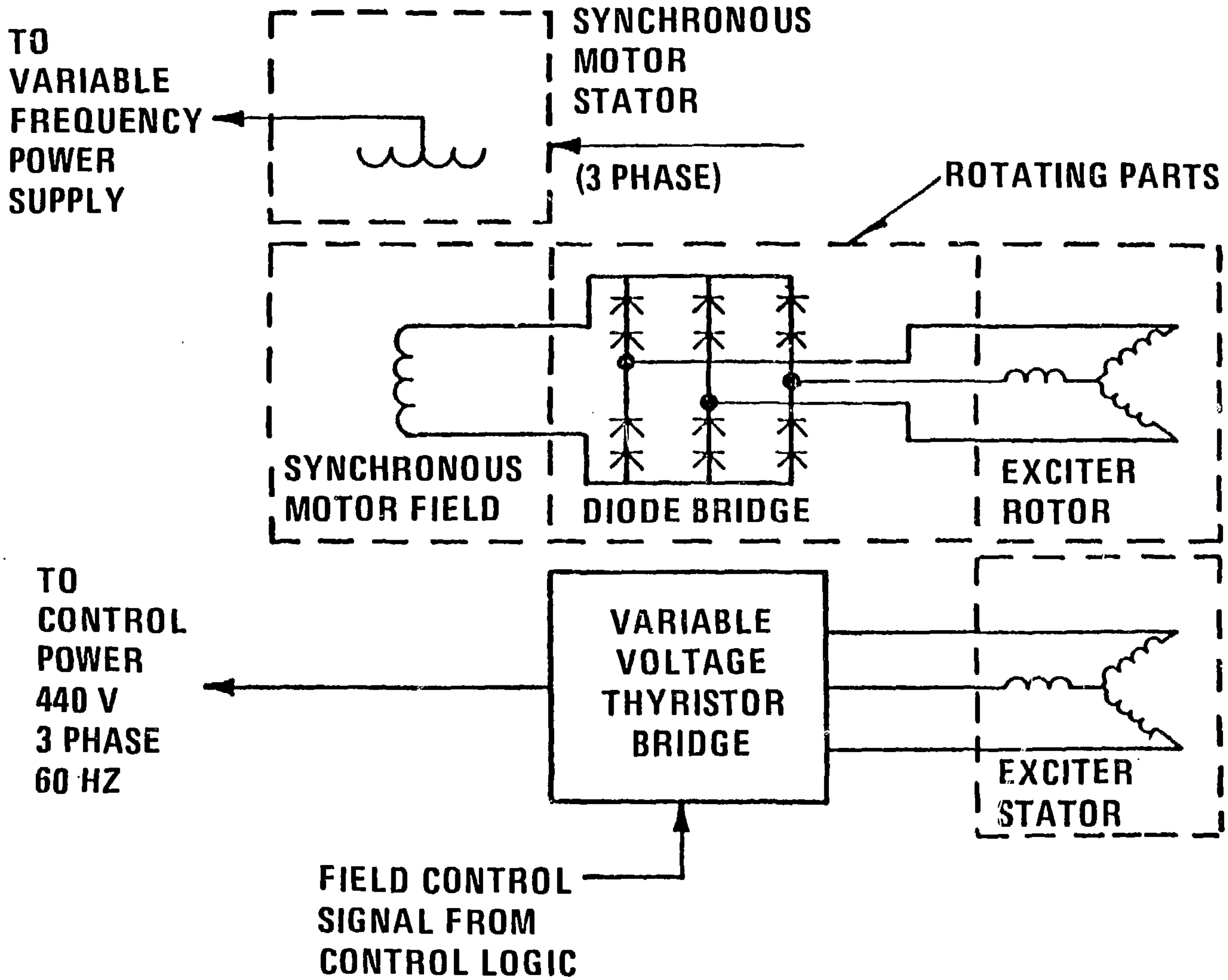
MAIN CIRCULATOR MOTOR – SCHEMATIC

GENERAL ATOMIC



F-850(1R)

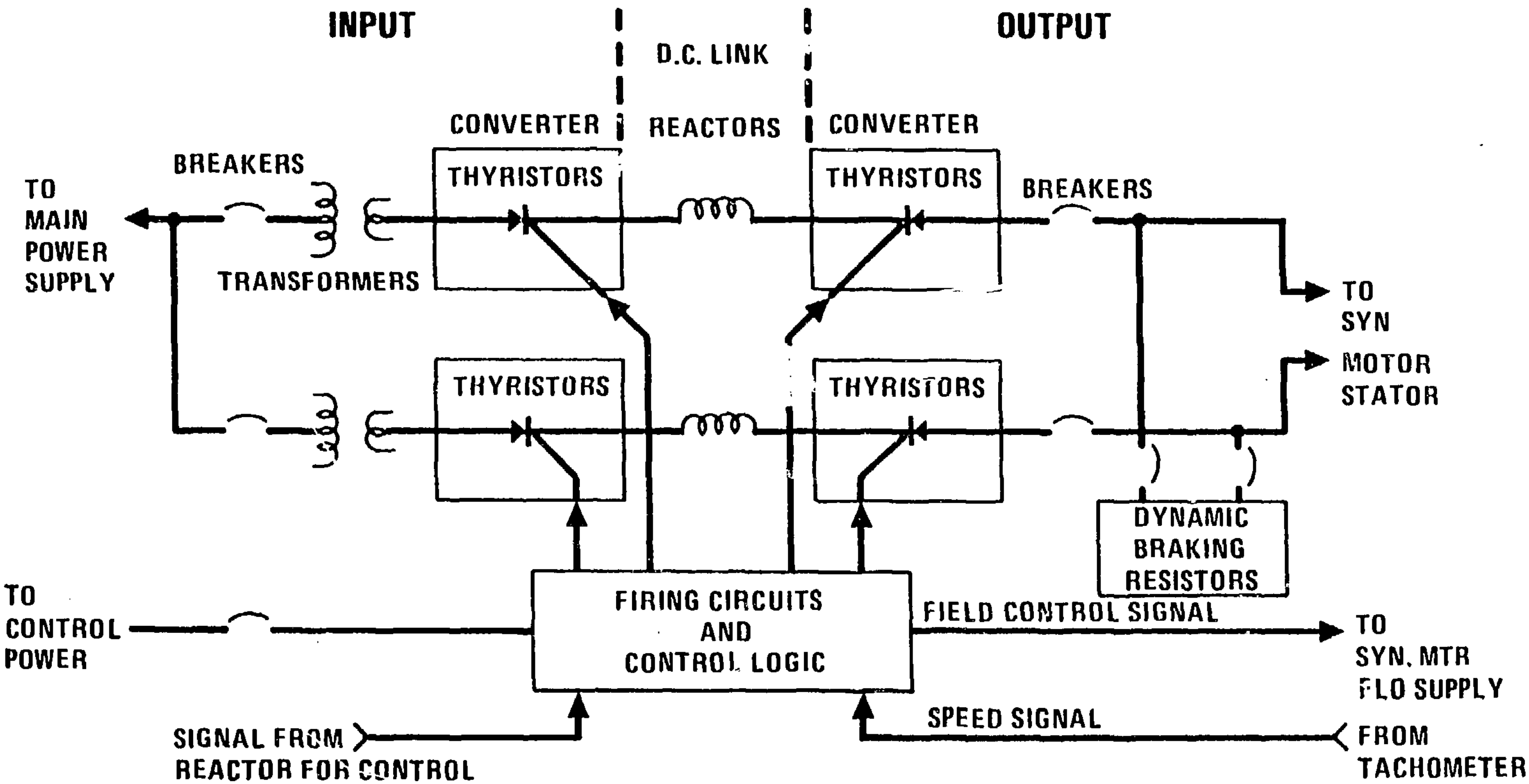
HTGR DRIVE MOTOR



F-767(2)

A48

HTGR POWER SUPPLY



F-767(4)

A49

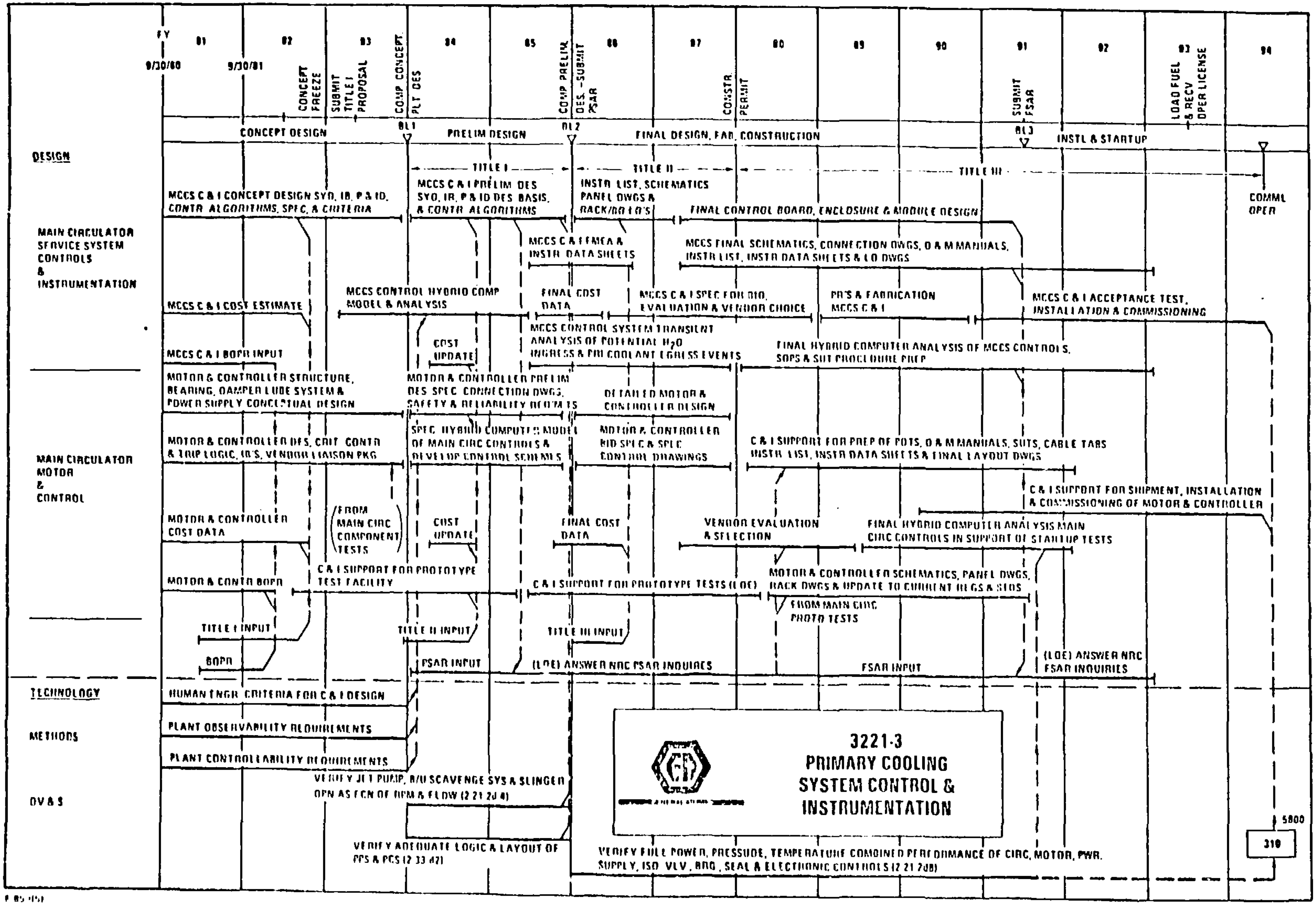
MOTOR SUPPLIER	TYPE	HP RATING	MOTOR RPM	MOUNTING	CUSTOMER	TYPE OF PLANT
ALLIS CHALMERS	SYNCHRONOUS 6 POLE	9000	1200 (CONSTANT)	VERTICAL		
ALLIS CHALMERS	SYNCHRONOUS 2 POLE	10000	3600 (CONSTANT)	HORIZONTAL		
ALLIS CHALMERS	SYNCHRONOUS	12000	1200	VERTICAL		
ALLIS CHALMERS	SYNCHRONOUS 4 POLE	14400	1800	HORIZONTAL		
WESTINGHOUSE	SYNCHRONOUS	15000	900 (CONSTANT)		CLARK BROTHERS	
WESTINGHOUSE	SYNCHRONOUS 4 POLE	1250/15000	300/3600 VARIABLE	HORIZONTAL	NASA CLEVELANO	
BROWN BOVERI	SYNCHRONOUS	12500	1500	HORIZONTAL	SAAKBERG WERKE BRD	STEEL MILL
BROWN BOVERI	SYNCHRONOUS	17500	1500		ARBED-SA LUXEMBURG	
BROWN BOVERI	SYNCHRONOUS	40000	3000		ISCOR WORKS JOHANNESBURG, S.A.	
	A.C.	12000	2980	HORIZONTAL	EDFI CHINON, FRANCE	MAGNOX REACTOR G.C.R.
	INDUCTION	9600	2240 VARI-SPEED	HORIZONTAL	DUNGENESS "A" U.K.	MAGNOX REACTOR G.C.R.
	INDUCTION (SLIP PING)	9850	1500 VARI-SPEED	HORIZONTAL	SIZEWELL U.K.	MAGNOX REACTOR G.C.R.
	A.C.	18900	2000	HORIZONTAL	WYLFA U.K.	MAGNOX REACTOR G.C.R.
SIEMENS	SYNCHRONOUS	30000	3000		ANBEO BELVAL	
SIEMENS	SYNCHRONOUS	18000	6000 VARI-SPEED	HORIZONTAL	ESSEN STADT IVERKE	FOSSIL FIRED POWER PLANT- -BFP DRIVE

GENERAL ATOMIC

MAIN CIRCULATOR CONTROL & ELECTRICAL DESIGN, SYSTEM 21

DESIGN DATA NEEDS

NEED	DESCRIPTION	PRIORITY	FACILITY	COST REV $
2.33.D.1	PERFORM HUMAN ENGINEERING STUDIES ON LOCAL AND REMOTE CONTROL SCHEMES, AND MAIN CONTROL ROOM AND REMOTE SHUTDOWN ROOM ARRANGEMENT AND FEATURES AS REQUIRED TO ASSURE THAT PLANT OPERATION CAN BE PROPERLY MONITORED AND CONTROLLED BY OPERATING PERSONNEL	T2 L1	FULL SCALE CONTROL ROOM SIMULATION WITH INTERFACE CAPABILITIES TO CONNECT EXPERIMENTAL COMPONENT TEST FACILITIES AND REAL TIME COMPUTER SIMULATION LABORATORY	SEE PCS DDN's
2.33.D.2	VERIFY ADEQUATE LOGIC AND LAYOUT OF PROTECTION AND CONTROL SYSTEMS	T2 L1	FULL SCALE MOCK-UP OF CONTROL ROOM BOARDS AND CONSOLES	SEE PCS DDN's
2.21.2D.4	VERIFY JET PUMP, B/U SCAVENGE SYSTEM AND SLINGER OPERATION AS A FUNCTION OF RPM AND FLOW	T1	FULL SCALE, FULL SPEED BEARING & SEAL TEST RIG	SEE MAIN CIRC. DDN's
2.21.2D.8	VERIFY FULL POWER PRESSURE, TEMPERATURE, COMBINED PERFORMANCE OF CIRCULATOR, MOTOR, POWER SUPPLY, ISOLATION VALVE, BEARING, SEAL & ELECTRONIC CONTROLS	T1	FULL POWER CIRCULATOR TEST FACILITY	SEE MAIN DDN's



FY
9/30/80
9/30/81
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89
90
91
92
93
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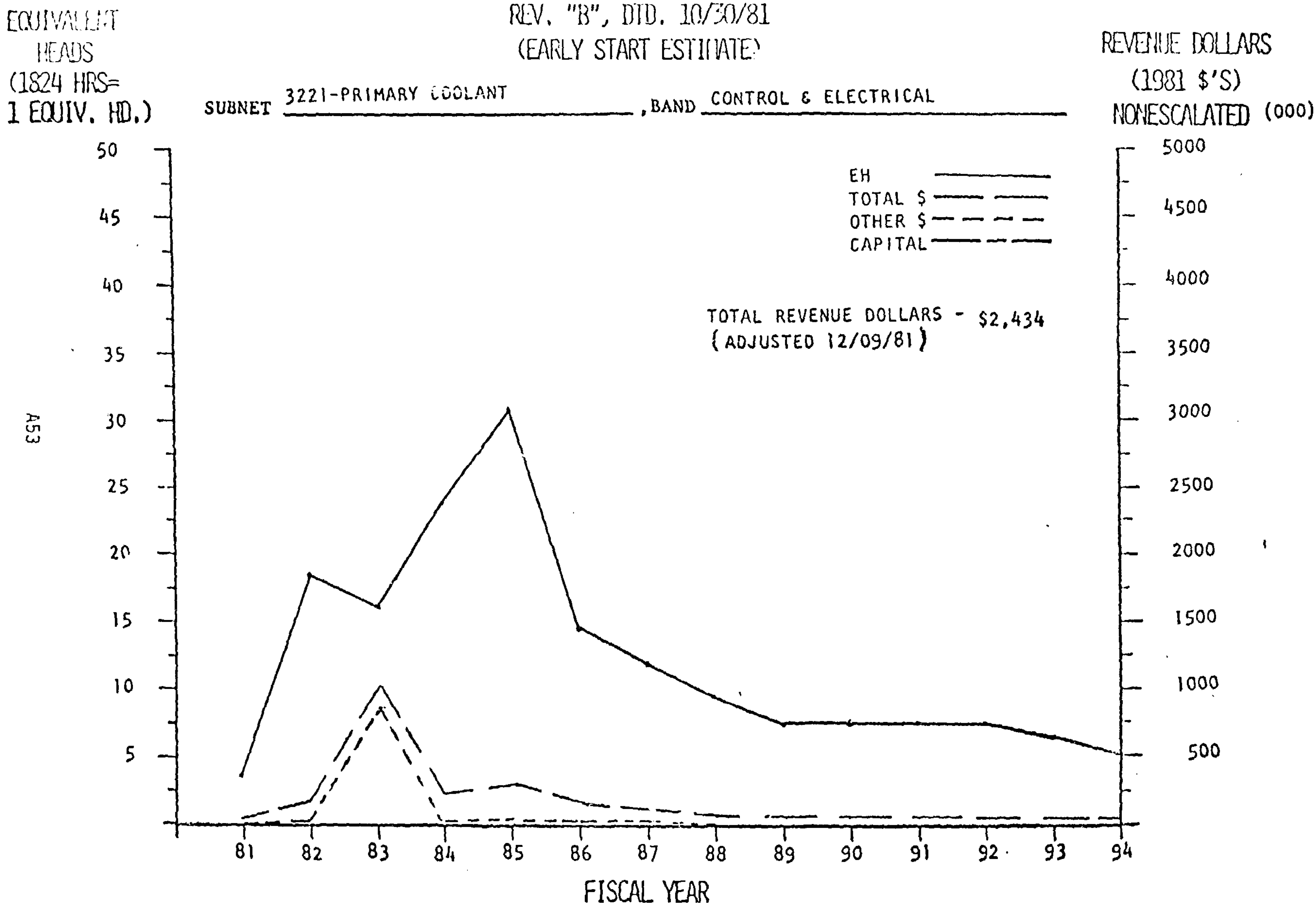
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP CONCEPT
PLT DES
COMP PRELIM
DES. -SUBMIT PSAR
CONSTR PERMIT
SUBMIT FSAR
LOAD FUEL & RECV OPER LICENSE
BL1
BL2
BL3
CONCEPT DESIGN
PRELIM DESIGN
FINAL DESIGN, FAB, CONSTRUCTION
INSTL & STARTUP
DESIGN
TITLE I
TITLE II
TITLE III
COMML OPER
MAIN CIRCULATOR SERVICE SYSTEM CONTROLS & INSTRUMENTATION
MCCS C & I CONCEPT DESIGN SYD, IB, P & ID, CONTR ALGORITHMS, SPEC, & CRITERIA
MCCS C & I PRELIM DES SYD, IB, P & ID DES BASIS, & CONTR ALGORITHMS
INSTR LIST, SCHEMATICS PANEL DWGS & RACK/BD LO'S
FINAL CONTROL BOARD, ENCLOSURE & MODULE DESIGN
MCCS C & I FMEA & INSTR DATA SHEETS
MCCS FINAL SCHEMATICS, CONNECTION DWGS, O & M MANUALS, INSTR LIST, INSTR DATA SHEETS & LO DWGS
MCCS C & I COST ESTIMATE
MCCS CONTROL HYBRID COMP MODEL & ANALYSIS
FINAL COST DATA
MCCS C & I SPEC FOR BID, EVALUATION & VENDOR CHOICE
PD'S & FABRICATION MCCS C & I
MCCS C & I ACCEPTANCE TEST, INSTALLATION & COMMISSIONING
MCCS C & I BOPR INPUT
COST UPDATE
MCCS CONTROL SYSTEM TRANSIENT ANALYSIS OF POTENTIAL H2O INGRESS & PRI COOLANT EGRESS EVENTS
FINAL HYBRID COMPUTER ANALYSIS OF MCCS CONTROLS, SOPS & SUT PROCEDURE PREP
MAIN CIRCULATOR MOTOR & CONTROL
MOTOR & CONTROLLER STRUCTURE, BEARING, DAMPER LUBE SYSTEM & POWER SUPPLY CONCEPTUAL DESIGN
MOTOR & CONTROLLER PRELIM DES SPEC CONNECTION DWGS, SAFETY & RELIABILITY REQM'TS
DETAILED MOTOR & CONTROLLER DESIGN
MOTOR & CONTROLLER DES, CRIT CONTR & TRIP LOGIC, ID'S, VENDOR LIAISON PKG
SPEC HYBRID COMPUTER MODEL OF MAIN CIRC CONTROLS & DEVELOP CONTROL SCHEMES
MOTOR & CONTROLLER BID SPEC & SPEC CONTROL DRAWINGS
C & I SUPPORT FOR PREP OF PDTS, O & M MANUALS, SUTS, CABLE TABS INSTR LIST, INSTR DATA SHEETS & FINAL LAYOUT DWGS
C & I SUPPORT FOR SHIPMENT, INSTALLATION & COMMISSIONING OF MOTOR & CONTROLLER
MOTOR & CONTROLLER COST DATA
(FROM MAIN CIRC COMPONENT TESTS)
COST UPDATE
FINAL COST DATA
VENDOR EVALUATION & SELECTION
FINAL HYBRID COMPUTER ANALYSIS MAIN CIRC CONTROLS IN SUPPORT OF STARTUP TESTS
MOTOR & CONTR BOPR
C & I SUPPORT FOR PROTOTYPE TEST FACILITY
C & I SUPPORT FOR PROTOTYPE TESTS (LOE)
MOTOR & CONTROLLER SCHEMATICS, PANEL DWGS, RACK DWGS & UPDATE TO CURRENT REGS & STDS
FROM MAIN CIRC PROTO TESTS
TITLE I INPUT
TITLE II INPUT
TITLE III INPUT
BOPR
PSAR INPUT
(LOE) ANSWER NRC PSAR INQUIRES
FSAR INPUT
(LOE) ANSWER NRC FSAR INQUIRIES
TECHNOLOGY
HUMAN ENGR CRITERIA FOR C & I DESIGN
METHODS
PLANT OBSERVABILITY REQUIREMENTS
PLANT CONTROLLABILITY REQUIREMENTS
DV & S
VERIFY JET PUMP, B/U SCAVENGE SYS & SLINGER OPN AS FCN OF RPM & FLOW (2 21 2d 4)
VERIFY ADEQUATE LOGIC & LAYOUT OF PPS & PCS (2 33 42)
VERIFY FULL POWER, PRESSURE, TEMPERATURE COMBINED PERFORMANCE OF CIRC, MOTOR, PWR. SUPPLY, ISO VLV, BRG, SEAL & ELECTRONIC CONTROLS (2 21 2dB)
3221-3
PRIMARY COOLING SYSTEM CONTROL & INSTRUMENTATION
5800
310

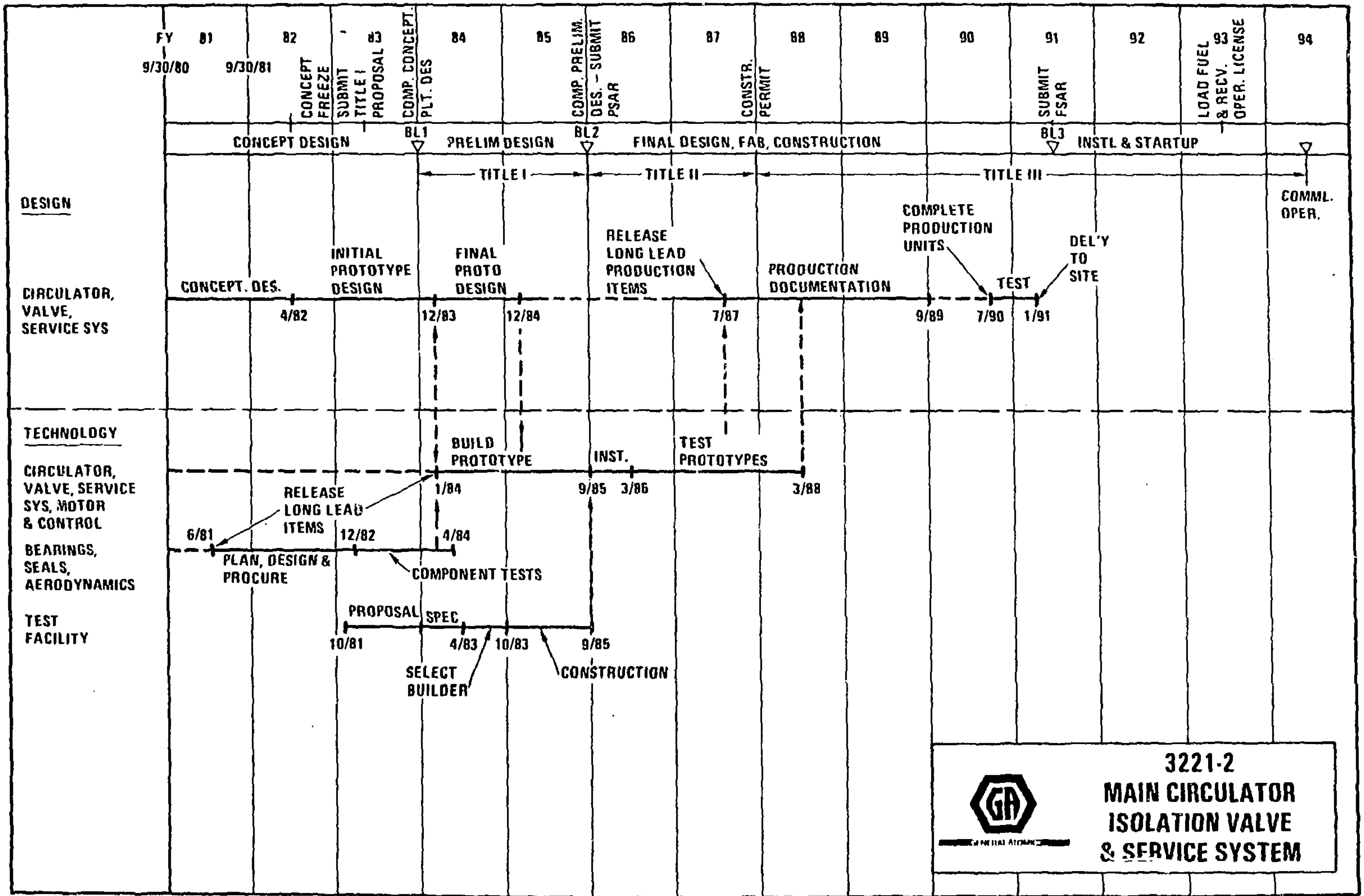
HTGR - SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

SUBNET 3221-PRIMARY COOLANT, BAND CONTROL & ELECTRICAL



NOTE: EARLY START - MANPOWER LOADING NOT YET OPTIMIZED/LEVEL LOADED

A53


FY 81 82 83 84 85 86 87 88 89 90 91 92 93 94
9/30/80 9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB, CONSTRUCTION
BL3
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
DESIGN
COMML. OPER.
CIRCULATOR, VALVE, SERVICE SYS
CONCEPT. DES.
4/82
INITIAL PROTOTYPE DESIGN
12/83
FINAL PROTO DESIGN
12/84
RELEASE LONG LEAD PRODUCTION ITEMS
7/87
PRODUCTION DOCUMENTATION
9/89
COMPLETE PRODUCTION UNITS
7/90
TEST
1/91
DEL'Y TO SITE
TECHNOLOGY
CIRCULATOR, VALVE, SERVICE SYS, MOTOR & CONTROL
BUILD PROTOTYPE
1/84
INST.
9/85
3/86
TEST PROTOTYPES
3/88
RELEASE LONG LEAD ITEMS
BEARINGS, SEALS, AERODYNAMICS
6/81
12/82
4/84
PLAN, DESIGN & PROCURE
COMPONENT TESTS
TEST FACILITY
PROPOSAL
SPEC
10/81
4/83
10/83
9/85
SELECT BUILDER
CONSTRUCTION
3221-2
MAIN CIRCULATOR ISOLATION VALVE & SERVICE SYSTEM

F-859(3)

MAIN CIRCULATOR DESIGN

* AERODYNAMICS
  - COMPRESSOR
  - DIFFUSER
  - INLET
* STRUCTURAL
  - MOTOR SUPPORT
  - CLOSURE
  - DUCTING
* BEARINGS & SEALS
* SERVICE SYSTEM
* LOOP ISOLATION VALVE

GENERAL ATOMIC

MAIN CIRCULATOR TECHNOLOGY

COMPONENT TESTS

* BEARINGS AND SEALS
  - . INTEGRAL PUMP
  - . WATER BEARING CHARACTERISTICS
  - . HELIUM/WATER SEAL
  - . DRAIN SYSTEM
  - . SERVICE SYSTEM
* SCALE MODEL AERODYNAMICS
  - . COMPRESSOR
  - . FLOW PATHS
  - . LOOP ISOLATION VALVE
* SHUTDOWN SEAL
* HIGH PRESSURE SLIDING SEAL

GENERAL ATOMIC

MAIN CIRCULATOR TECHNOLOGY

PROTOTYPE TESTS

REACTOR INSTALLATION CONFIGURATION

* SIMULATED REACTOR ENVIRONMENT
    - HELIUM
    - FULL TEMPERATURE
    - FULL PRESSURE/DEPRESSURIZED
    - TRANSIENTS

* COMPLETE PERFORMANCE EVALUATION
    - AERODYNAMICS
    - BEARINGS & SEALS
    - SERVICE SYSTEMS
    - MOTOR
    - MOTOR CONTROLLER
    - INSTRUMENTATION
    - LOOP ISOLATION VALVE

GENERAL ATOMIC

MAIN CIRCULATOR SC/C PROGRAM COSTS

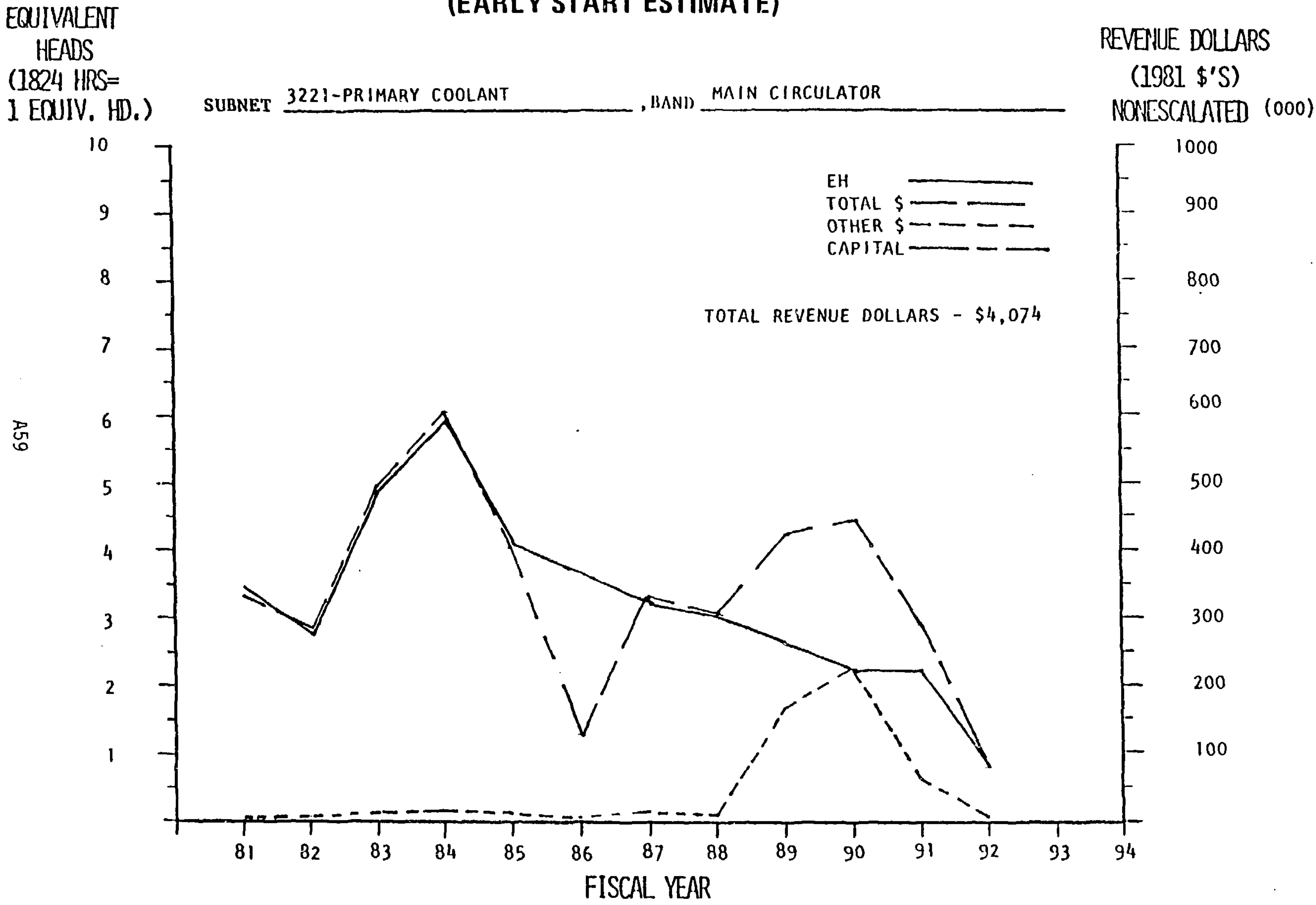
INCLUDING MAIN LOOP ISOLATION
VALVE AND SERVICE SYSTEM
1981 $

DESIGN COSTS	$\$ 4.07 \times 10^6$
TECHNOLOGY COSTS	$\$ 4.87 \times 10^6$
HARDWARE & CAPITAL COSTS*	$\$10.47 \times 10^6$
TOTAL PROGRAM COST	$\$19.41 \times 10^6$

*INCLUDES $\$5.85 \times 10^6$ FOR PROTOTYPE TEST FACILITY

GENERAL ATOMIC

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)



N EARLY START - MANPOWER LOADING NOT YET OPTIMI LEVEL LOADED

MAIN CIRCULATOR TECHNOLOGY
MATERIALS TESTS

DDN	DESCRIPTION
2.21.2.A.1	* - OBTAIN FRACTURE MECHANICS DATA ON FORGED AND WELDED ROTATING MACHINERY MATERIAL * - BENCH TESTS * - PRIORITY - T2 * - COST - $200K

NOTE: SAME AS PROGRAM FOR AUXILIARY CIRCULATOR (DDN 2.28.2.A.1)

MAIN CIRCULATOR TECHNOLOGY
MATERIALS TESTS

DDN	DESCRIPTION
2.21.2.A.2	* - OBTAIN CODE APPROVAL OF INCONEL 718 FOR USE IN SHUTDOWN SEAL BELLOWS * - BENCH TESTS * - PRIORITY - T2 * - COST - $481K

MAIN CIRCULATOR TECHNOLOGY

BEARINGS & SEALS COMPONENT TESTS

DDN	DESCRIPTION
2.21.2.D.1, 2, 3 & 4	* - DETERMINE PERFORMANCE CHARACTERISTICS OF WATER BEARING, INTEGRAL PUMP, HELIUM/WATER SEAL, HELIUM/WATER DRAINS AND SERVICE SYSTEM
	* - FULL SCALE BEARING TEST RIG
	* - PRIORITY - T1
	* - COST - $2,297K

GENERAL ATOMIC

MAIN CIRCULATOR TECHNOLOGY
SHUTDOWN SEAL COMPONENT TEST

DDN	DESCRIPTION
2.21.2.D.5	* - DEMONSTRATE SHUTDOWN SEAL DURABILITY AND RESISTANCE TO FLOW EXCITATION * - BENCH TEST RIG * - PRIORITY - T2 * - COST - $283K

A63

MAIN CIRCULATOR TECHNOLOGY
WATER/AIR SEAL COMPONENT TEST

DDN	DESCRIPTION
2.21.2.D.6	* - CONFIRM HIGH PRESSURE WATER/AIR SLIDING SEAL PERFORMANCE * - BENCH TEST RIG * - PRIORITY - T2 * - COST - $283K

GENERAL ATOMIC

MAIN CIRCULATOR TECHNOLOGY
AERODYNAMICS COMPONENT TESTS

DDN	DESCRIPTION
2.21.2.D.7	* - DETERMINE AERODYNAMIC PERFORMANCE OF MAIN CIRCULATOR COMPRESSOR, FLOW PATHS AND LOOP ISOLATION VALVE INCLUDING REVERSE FLOW * - 1/3 SCALE TEST RIG USING AIR * - PRIORITY - T2 * - COST - $1,582K

GENERAL ATOMIC

MAIN CIRCULATOR TECHNOLOGY
PROTOTYPE TESTS

DDN	DESCRIPTION
2.21.2.D.8, 9 & 10	* - VERIFY PERFORMANCE OF PROTOTYPE HARDWARE UNDER SIMULATED REACTOR CONDITIONS INCLUDING CIRCULATOR, VALVE, SERVICE SYSTEM, MOTOR, MOTOR CONTROL AND ALL RELATED INSTRUMENTATION
	* - FULL SIZE, SPECIALIZED TEST FACILITY
	* - PRIORITY - T1
	* - COST - $3,154K - TESTS & LABOR 1,886K - HARDWARE 5,850K - FACILITY $10,525K

GENERAL ATOMIC

HTGR AUXILIARY CIRCULATOR

A67

GENERAL ATOMIC COMPANY

AUXILIARY CIRCULATOR REQUIREMENTS

GENERAL ATOMIC

A. SAFETY

1. FUNCTION IS SAFETY CLASSIFIED.
2. PRIMARY BOUNDARIES SAFETY CLASSIFIED.
3. SEISMIC, DBDA AND STEAM/AIR INGRESS NOT TO CAUSE THE LOSS OF FUNCTION.
4. ROTOR BURST NOT BREACH PRIMARY COOLANT BOUNDARY AND OTHER SYSTEMS FOR SHUT DOWN COOLING.

A69

B. FUNCTIONAL

1. CIRCULATE AND CONTROL THE PRIMARY COOLANT FLOW AT ALL REACTOR CONDITIONS WITH ZERO REACTOR POWER.
2. CAPABLE OF DEMONSTRATING OPERABILITY DURING POWER OPERATION.
3. SURGE MARGIN SAME AS MAIN CIRCULATOR (20%).
4. PREVENT INGRESS OF LUBRICANT AND PRIMARY COOLANT SAME AS FOR THE MAIN CIRCULATOR.

F-902(3)

GENERAL ATOMIC

AUXILIARY LOOP ISOLATION VALVE REQUIREMENTS

A69

A. SAFETY

1. FUNCTION IS SAFETY CLASSIFIED.
2. PASSIVE ACTUATION PLUS MANUAL ASSIST, AND POSITION INDICATION.
3. SEISMIC, DBDA AND STEAM/AIR INGRESS NOT TO CAUSE THE LOSS OF FUNCTION.
4. ONE OUT OF THREE VALVES TO BE DIVERSE IN DESIGN.

B. FUNCTIONAL

1. PREVENT THE BACK FLOW OF PRIMARY COOLANT.
2. FORWARD FLOW AND GRAVITY OPEN, BACK FLOW CLOSED.
3. CLOSE UNDER MINIMUM REVERSE FLOW.

HTGR – PS/C AUXILIARY CIRCULATOR PERFORMANCE REQUIREMENTS DURING THE DBDA

GENERAL ATOMIC

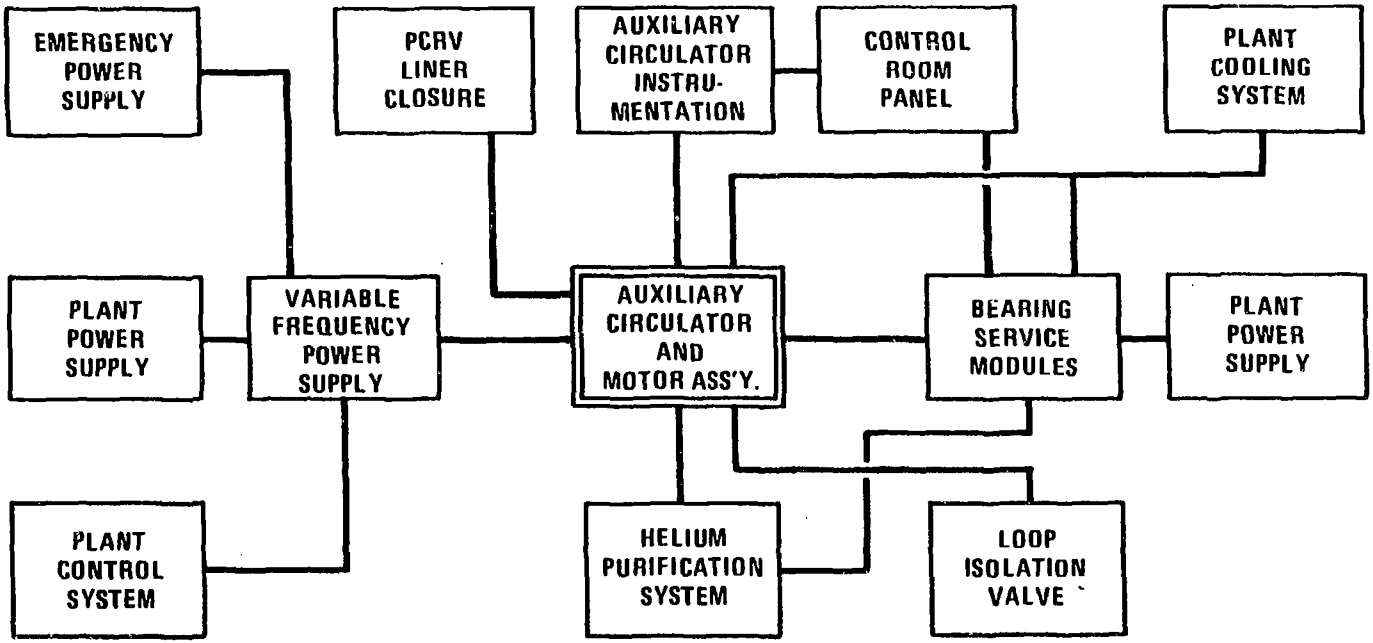
A70

INLET GAS CONDITIONS:*	
PRESSURE, PSIA	23.6
TEMPERATURE, ^{0}F	660
DENSITY, LB/CU.FT.	0.024
MOLECULAR WT.	12
FLOW PER CIRCULATOR, LB/HR	140,000
LOOP ΔP, PSI	0.96
SHAFT HORSEPOWER	226

*NOTE: PRESSURIZED OPERATION AT 1050 PSI REQUIRES MUCH LOWER AUXILIARY CIRCULATOR DUTY

F-766(9)R

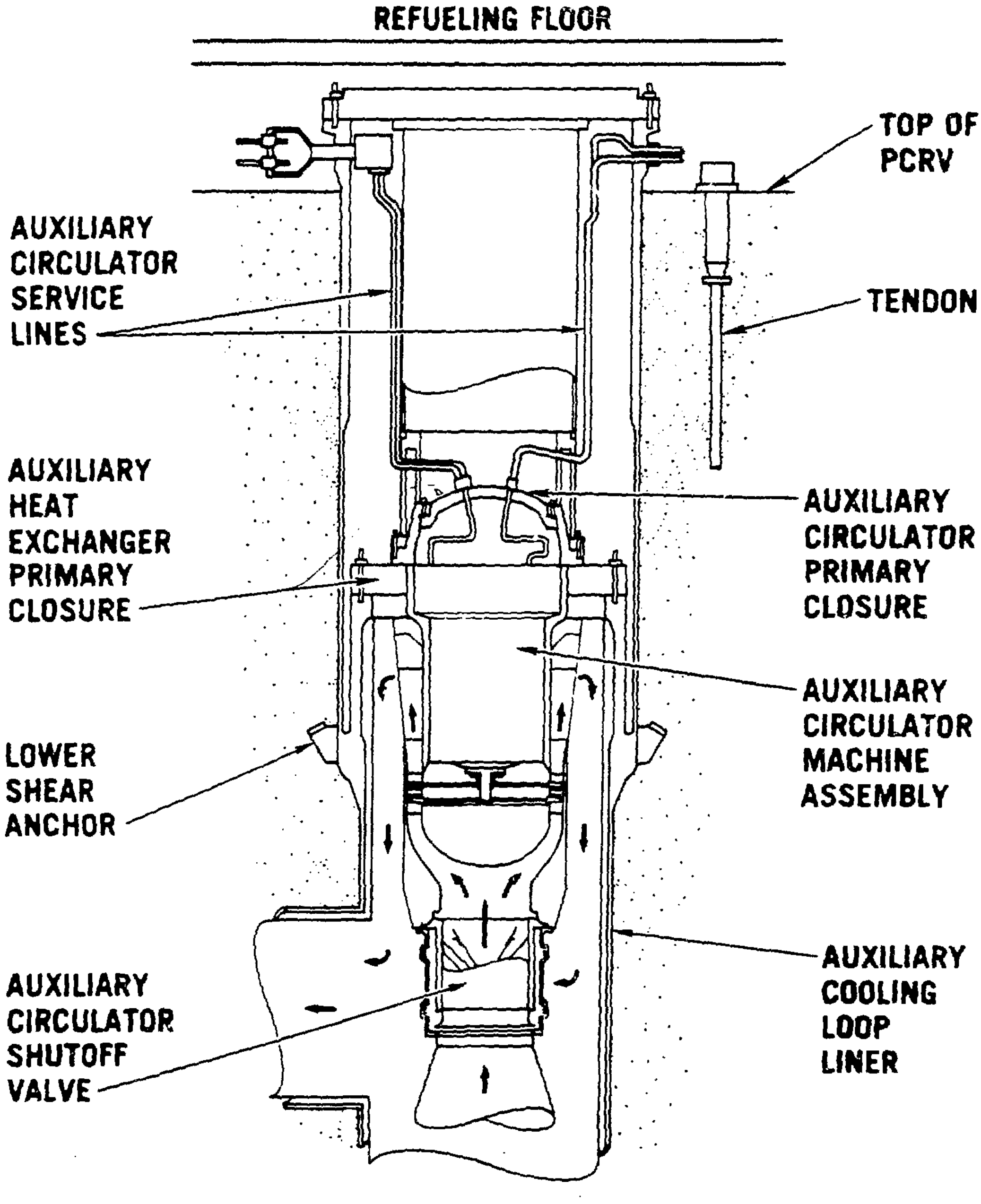
AUXILIARY CIRCULATOR INTERFACES



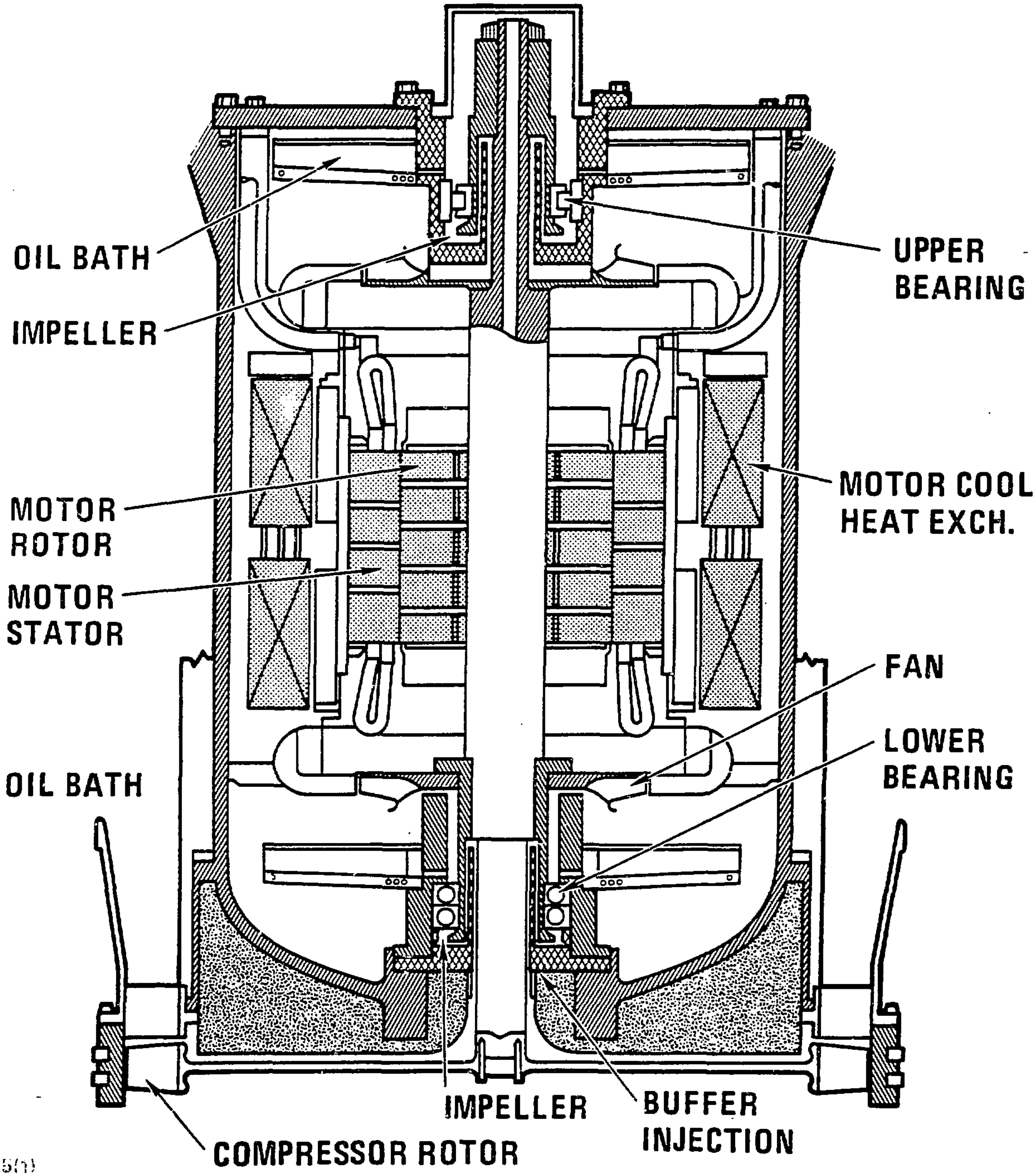
A71

F-890(3)

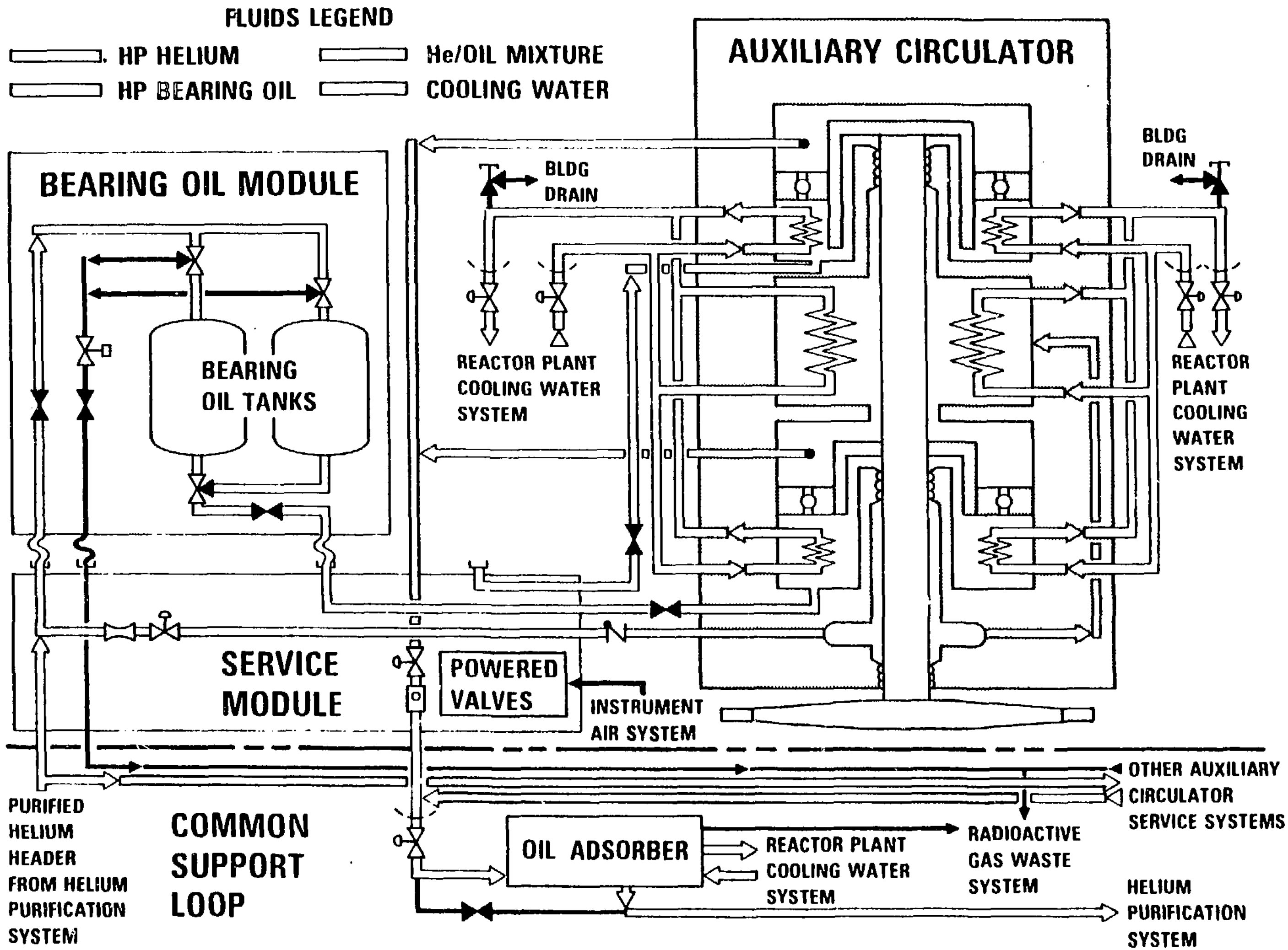
AUXILIARY CIRCULATOR INSTALLATION



AUX. CIRC. MOTOR



AUXILIARY CIRCULATOR SERVICE SYSTEM FLOW DIAGRAM



A74

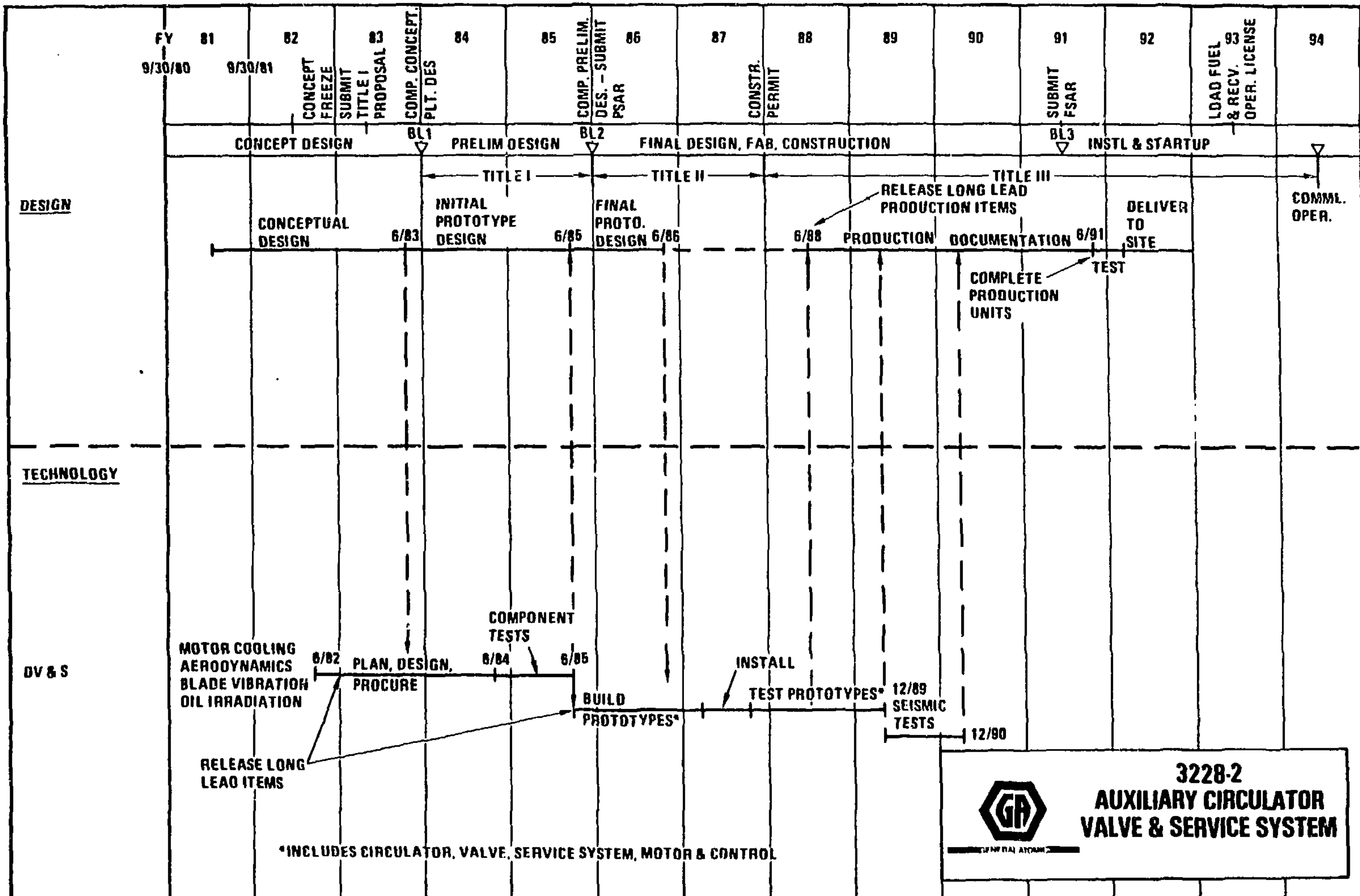
HTGR AUXILIARY CIRCULATOR STATUS OF DESIGN AND TECHNOLOGY

GENERAL ATOMIC

1. BEARINGS AND SEALS TEST IN HELIUM COMPLETED.
2. 700 KW VARIABLE FREQUENCY POWER SUPPLY SHOP TESTED AND DELIVERED.
3. PROTOTYPE SUBMERGED MOTOR ROTOR AND STATOR WERE MANUFACTURED BUT NOT SHOP TESTED.
4. 60% OF ALL DESIGN ANALYSES FOR DELMARVA CONFIGURATION HAVE BEEN COMPLETED.
5. DESIGN DRAWINGS FOR DELMARVA PROTOTYPE WERE COMPLETED.
6. FULL SCALE TEST FACILITY DESIGN COMPLETED AND PRESSURE VESSEL FOUNDATION AND POWER SUPPLY INSTALLED.

A75

F-766(8)R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9/30/80
9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB, CONSTRUCTION
BL3
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
DESIGN
CONCEPTUAL DESIGN
6/83
INITIAL PROTOTYPE DESIGN
6/85
FINAL PROTO. DESIGN
6/86
RELEASE LONG LEAD PRODUCTION ITEMS
6/88
PRODUCTION
DOCUMENTATION
6/91
DELIVER TO SITE
COMML. OPER.
TEST
COMPLETE PRODUCTION UNITS
TECHNOLOGY
DV & S
MOTOR COOLING
AERODYNAMICS
BLADE VIBRATION
OIL IRRADIATION
6/82
PLAN, DESIGN, PROCURE
6/84
COMPONENT TESTS
6/85
BUILD PROTOTYPES*
INSTALL
TEST PROTOTYPES*
12/89
SEISMIC TESTS
12/90
RELEASE LONG LEAD ITEMS
*INCLUDES CIRCULATOR, VALVE, SERVICE SYSTEM, MOTOR & CONTROL
GA
GENERAL ATOMIC
3228-2
AUXILIARY CIRCULATOR VALVE & SERVICE SYSTEM

F-859(8)

GENERAL ATOMIC

AUXILIARY CIRCULATOR DESIGN

* AERODYNAMICS
  - . COMPRESSOR
  - . DIFFUSER
  - . INLET
* STRUCTURAL
  - . CLOSURES
  - . LIMIT STOP
  - . DUCTING
* MOTOR COOLING
  - . FANS
  - . HEAT EXCHANGER
* BEARINGS
* SERVICE SYSTEM
* LOOP ISOLATION VALVE

AUXILIARY CIRCULATOR TECHNOLOGY
COMPONENT TESTS

* MOTOR COOLING
  . FANS
  . HEAT EXCHANGER
  . MOTOR PASSAGES
* SCALE MODEL AERODYNAMICS
  . COMPRESSOR
  . FLOW PATHS
  . LOOP ISOLATION VALVE
* OIL IRRADIATION
* BLADE VIBRATION

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
PROTOTYPE QUALIFICATION TESTS
REACTOR INSTALLATION CONFIGURATION

* SIMULATED REACTOR ENVIRONMENT
  . HELIUM
  . FULL TEMPERATURE
  . FULL PRESSURE/DEPRESSURIZED
  . TRANSIENTS
* COMPLETE PERFORMANCE EVALUATION
  . AERODYNAMICS
  . MOTOR COOLING
  . BEARINGS & SEALS
  . SERVICE SYSTEMS
  . MOTOR CONTROLLER
  . INSTRUMENTATION
  . LOOP ISOLATION VALVE
* SEISMIC

AUXILIARY CIRCULATOR TECHNOLOGY

MATERIALS TESTS

DDN	DESCRIPTION
2.28.2.A.1	* - OBTAIN FRACTURE MECHANICS DATA ON FORGED AND WELDED ROTATING MACHINERY MATERIAL.
	* - BENCH TESTS
	* - PRIORITY - T2
	* - COST - $200K

NOTE: SAME AS PROGRAM FOR MAIN CIRCULATOR (DDN 2.21.2.A.1)

A80

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
MOTOR COOLING COMPONENT TEST

DDN	DESCRIPTION
2.28.2.D.1	* - VERIFY ADEQUACY OF COOLING SYSTEM FOR SUBMERGED MOTOR; EVALUATE PERFORMANCE OF HEAT EXCHANGER, SHAFT-MOUNTED FANS AND ROTOR/STATOR FLOW PASSAGES.
	* - FULL SCALE TEST USING AIR
	* - PRIORITY - T2
	* - COST - $702K

A81

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
AERODYNAMICS COMPONENT TESTS

DDN	DESCRIPTION
2.28.2.D.2	* - DETERMINE AERODYNAMIC PERFORMANCE OF AUXILIARY CIRCULATOR COMPRESSOR, FLOW PATHS AND LOOP ISOLATION VALVE INCLUDING REVERSE FLOW.
	* - 1/3 SCALE TEST RIG USING AIR.
	* - PRIORITY - T2
	* - COST - $942K

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
OIL IRRADIATION TESTS

DDN	DESCRIPTION
2.28.2.D.3	* - ESTABLISH OIL DEGRADATION DUE TO RADIATION.
	* - CAPSULE TEST
	* - PRIORITY - T2
	* - COST - $89K

A83

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
BLADE VIBRATION COMPONENT TEST

DDN	DESCRIPTION
2.28.2.D.7	* - VERIFY CALCULATED VIBRATION CHARACTERISTICS OF COMPRESSOR BLADES
	* - BENCH TEST
	* - PRIORITY - T2
	* - COST - $223K

A84

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
PROTOTYPE QUALIFICATION TESTS

DDN	DESCRIPTION
2.28.2.D.4	* - VERIFY PERFORMANCE OF PROTOTYPE HARDWARE UNDER SIMULATED REACTOR CONDITIONS INCLUDING CIRCULATOR, VALVE, SERVICE SYSTEM, MOTOR, MOTOR CONTROL AND ALL RELATED INSTRUMENTATION
	* - FULL SIZE, SPECIALIZED TEST FACILITY
	* - PRIORITY - L1
	* - COST - $1,422K - TESTS & LABOR 3,000K - HARDWARE 3,000K - FACILITY $7,422K - TOTAL

GENERAL ATOMIC

AUXILIARY CIRCULATOR S/C PROGRAM COSTS

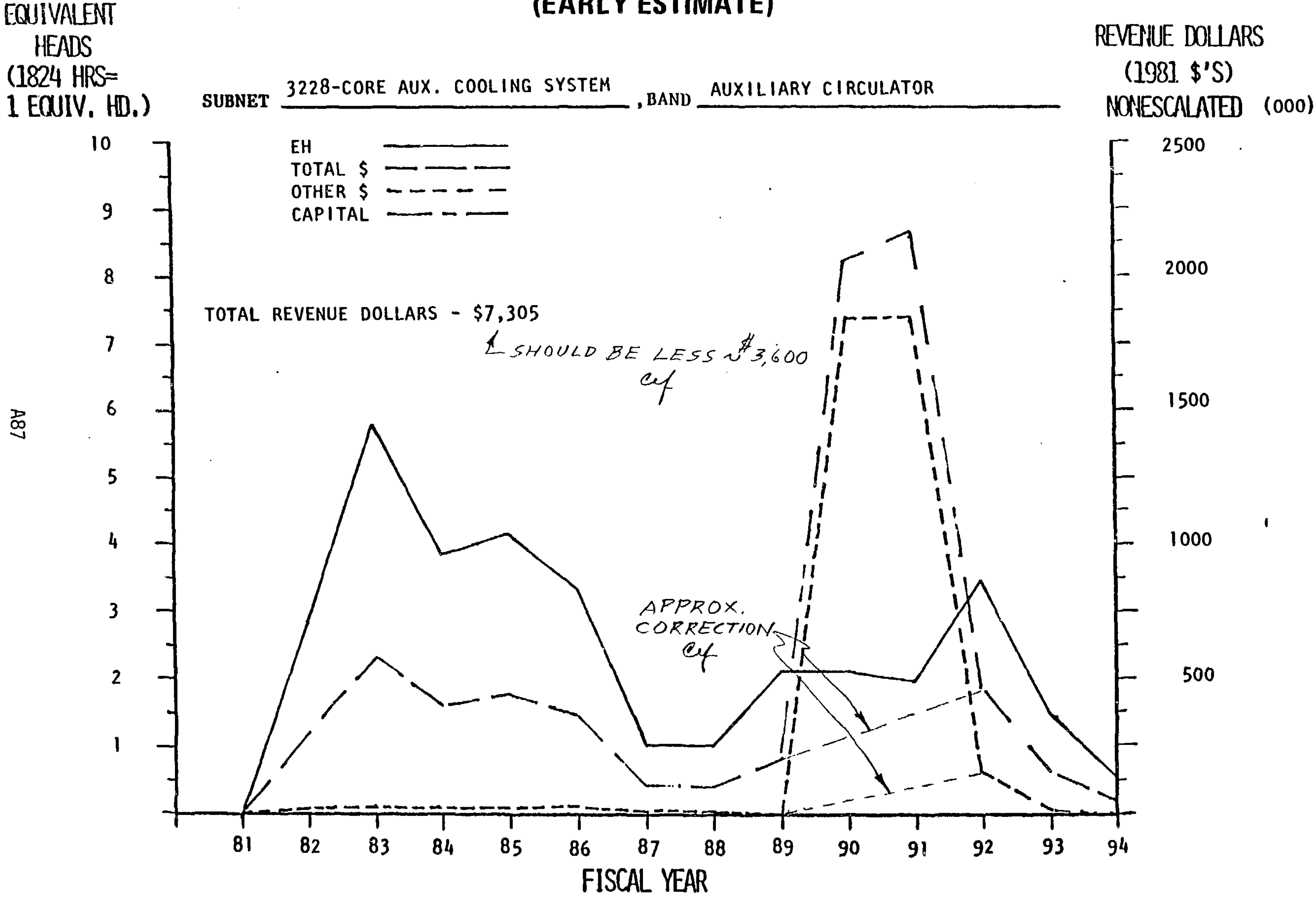
INCLUDING AUXILIARY LOOP ISOLATION
VALVE AND SERVICE SYSTEM
1981 $

DESIGN COSTS	$ 3.70 X 10^6
TECHNOLOGY COSTS	$ 2.94 X 10^6
HARDWARE & CAPITAL COSTS*	$ 7.67 X 10^6
TOTAL PROGRAM COST	$14.31 X 10^6

*INCLUDES MOTOR & CONTROLLER AND $3.0 X 10^6
FOR PROTOTYPE TEST FACILITY

GENERAL ATOMIC

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY ESTIMATE)



NOTE [illegible] LY START - MANPOWER LOADING NOT YET OPTIMIZED [illegible] L LOADED

GENERAL ATOMIC

AUXILIARY CIRCULATOR TECHNOLOGY
PROTOTYPE SEISMIC TESTS

DDN	DESCRIPTION
2.28.2.D.5	* - VERIFY OPERABILITY OF PROTOTYPE CIRCULATOR ASSEMBLY DURING SAFE SHUTDOWN EARTHQUAKE (SSE) SEISMIC CONDITIONS
	* - FULL SIZE SEISMIC FACILITY
	* - PRIORITY - L1
	* - COST - $1,028K

GENERAL ATOMIC

DESIGN

CACS HARDWARE INCLUDES:

- AUXILIARY CIRCULATOR ELECTRIC DRIVE SYSTEM
- CORE AUXILIARY HEAT EXCHANGER (CAHE)
- CONTROLS & INSTRUMENTATION

DESIGN & DEVELOP CONTROL & ELECTRICAL FOR CORE AUXILIARY COOLING SYSTEM.

- DRIVE SYSTEM CONSISTS OF INVERTER-POWER SUPPLY, CONTROLLER & MOTOR FOR AUXILIARY CIRCULATOR
- CACS CONTROLS & INSTRUMENTATION

  THE DESIGN STARTS IN THE CONCEPTUAL DESIGN PHASE & EXTENDS TO THE FINAL DESIGN & DEVELOPMENT PHASES & POST INSTALLATION FIELD TESTING.

OVERALL OBJECTIVE – PROVIDE DOCUMENTATION TO DESIGN, BUILD, TEST, LICENSE & OPERATE THE CAHE DRIVE SYSTEM.

- PPS INITIATES SYSTEM 47 SEQUENCER WHICH TRANSFERS CACS FROM STANDBY TO OPERATE MODE
- CACS INTERFACES WITH NSS & BOP SYSTEMS
- ENSURE CACS MEETS NRC-IEEE REQUIREMENTS FOR CORE COOLING & REACTOR SHUTDOWN.
- DESIGN & TEST PROTOTYPE ELECTRIC MOTOR & CONTROLLER & SPECIFY PRODUCTION UNITS

F-866(1)

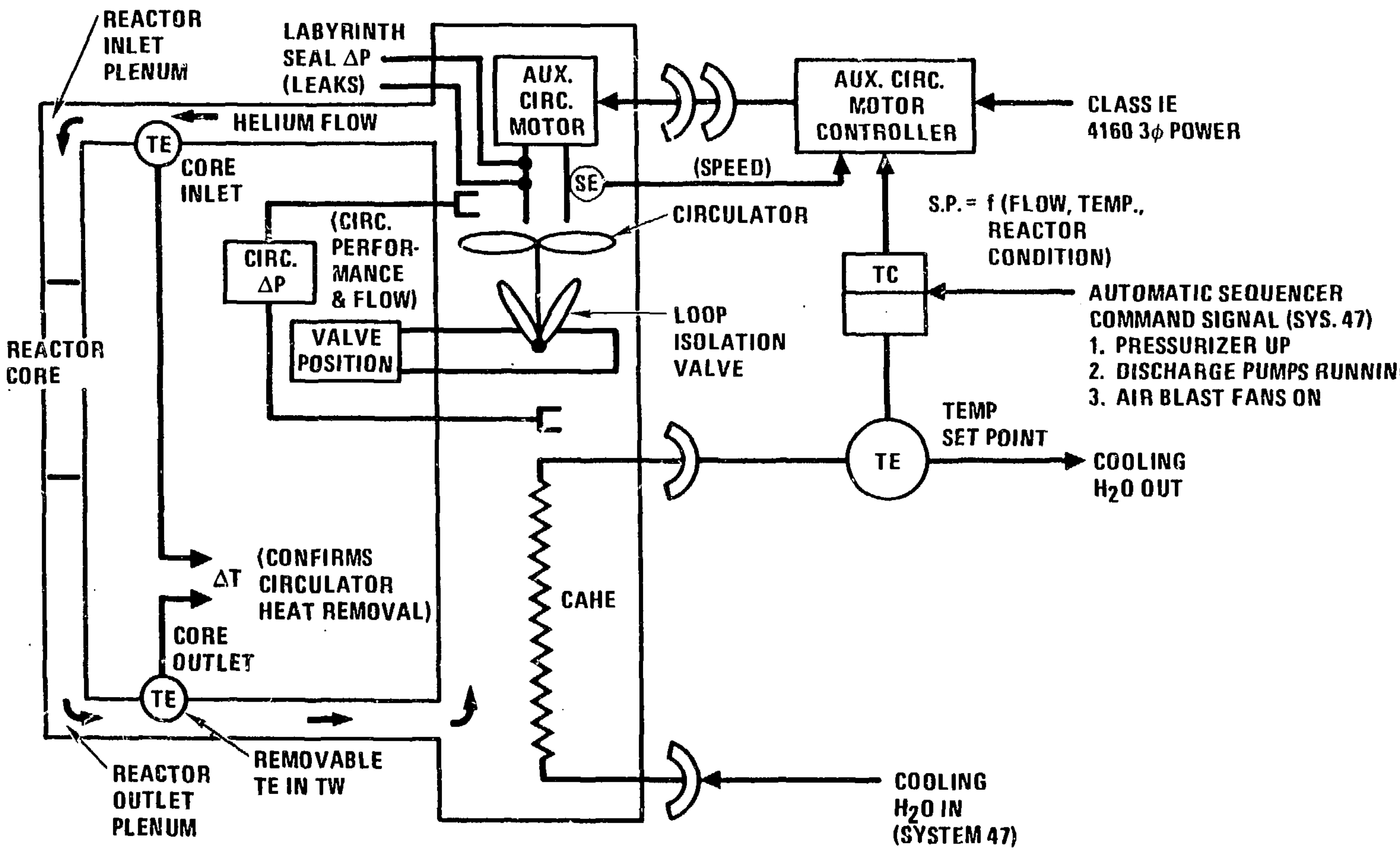
GENERAL ATOMIC

HTGR MAIN CIRCULATOR STATUS OF DESIGN AND TECHNOLOGY

1. HIGH LOAD CAPACITY, HIGH STIFFNESS WATER BEARING TECHNOLOGY IS FULLY DEVELOPED AND UNDERSTOOD.
2. THE BEARING AND SEAL SYSTEM "LESSONS LEARNED" RE WATER INGRESS AT FSV HAVE BEEN INCORPORATED INTO THE NEW DESIGN.
3. ALL THE DESIGN CODES AND METHODS NEEDED TO PERFORM THE CIRCULATOR DETAIL DESIGN ARE ON HAND.
4. NEW CONFIGURATIONS OF ELECTRIC MOTOR DRIVEN, CENTRIFUGAL FLOW CIRCULATORS AND LOOP ISOLATION VALVES HAVE BEEN DEVELOPED IN THE CONCEPTUAL STAGE.
5. AERODYNAMIC, BEARINGS, CRITICAL SPEEDS AND SEALS ANALYSES WERE CONDUCTED FOR THE NEW CONFIGURATIONS.
6. CONCEPTUAL DESIGN EFFORT AND FEASIBILITY STUDIES ON THE ELECTRIC MOTOR DRIVE SYSTEM HAVE BEEN COMPLETED BY AN ELECTRIC MOTOR VENDOR.
7. BEARINGS AND SEALS VERIFICATION TEST PROGRAM WAS INITIATED IN OCTOBER 1979. THE DESIGN OF THE FULL SCALE, FULL RPM TEST RIG INCORPORATING INTEGRAL PUMP, BEARING AND HELIUM/WATER SEAL IS NOW 90% COMPLETED.

F-766(2)R

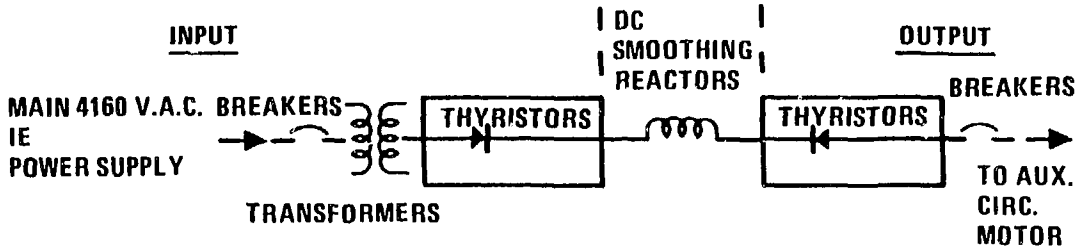
P&I DIAGRAM
CORE AUXILIARY COOLING SYSTEM



A90

F-866(2)

AUXILIARY CIRCULATOR POWER SUPPLY



AUXILIARY CIRCULATOR CONTROL BY VARYING 4160 VAC FREQUENCY AMPLITUDE TO MOTOR

- 4160 VAC FROM TRANSFORMER
- RECTIFIED & SMOOTHED BY THYRISTOR BRIDGES & DC REACTORS
- DC INVERTED TO AC TO RUN MOTOR AT REQUIRED SPEED (FREQUENCY CONTROL)

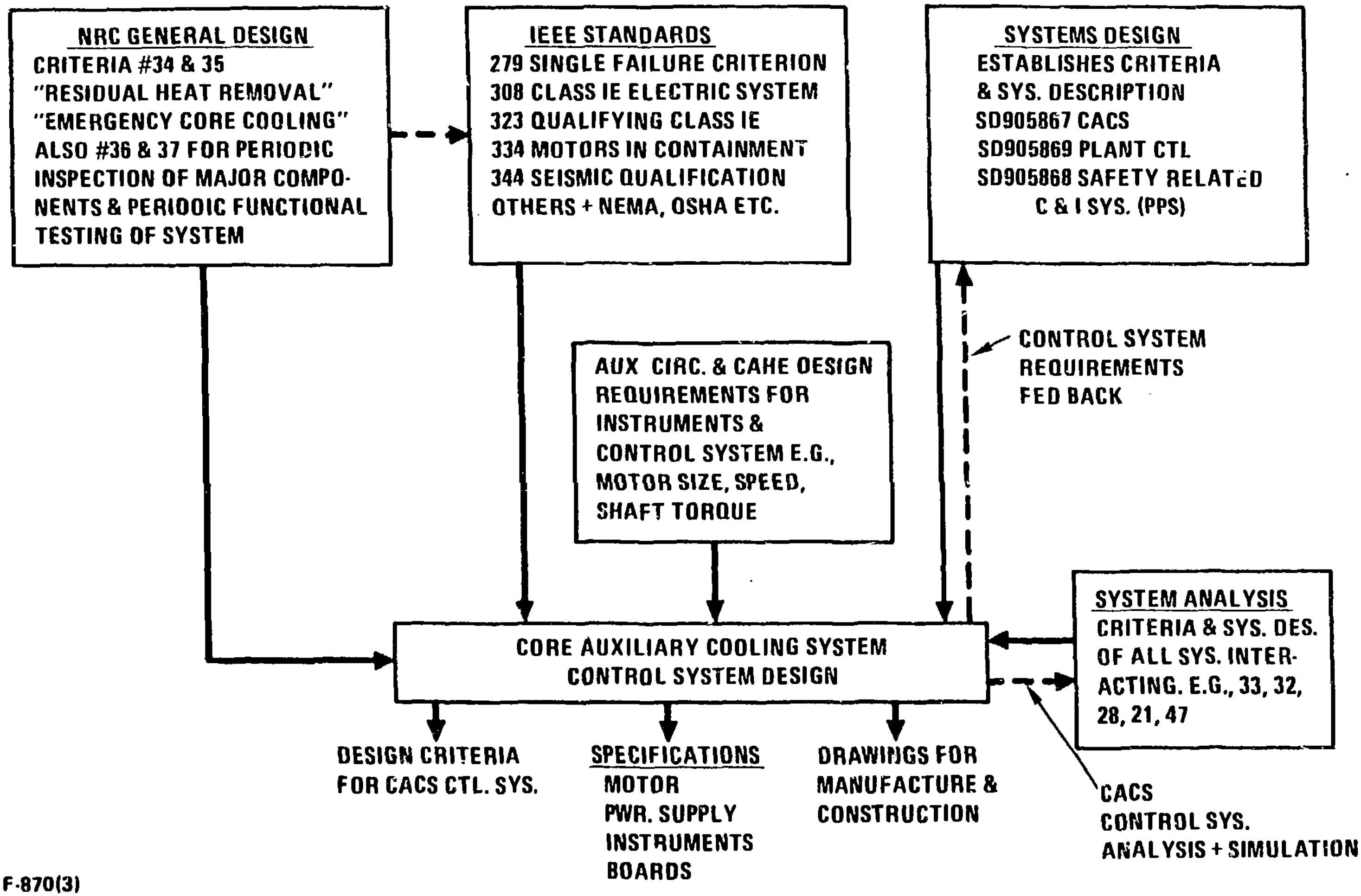
MOTOR PROTECTION

- OVER CURRENT (1ϕ)
- STATOR WINDING HOT SPOT (2 PER ϕ)
- MOTOR COOLING WATER (2 LOOPS)

SRDI

- MOTOR BEARING OIL TEMPERATURE
- MOTOR BEARING OIL LEVEL
- PRIMARY COOLANT INTO CACWS (PRESSURIZED)
- H_2O INTO PRIMARY COOLANT (IDENTIFY LEAKING CACWS LOOP)
- CIRCULATOR CONTROLLER FREQUENCY
- LOOP ISOLATION VALVE POSITION
- CAHE INLET & OUTLET GAS TEMPERATURE
- CAHE OUTLET WATER TEMPERATURE

GENERAL ATOMIC



F-870(3)

GENERAL ATOMIC

EVOLUTION FROM FSV DESIGN

FSV HELIUM CIRCULATORS DRIVEN BY

- STEAM TURBINE DURING NORMAL OPERATION
- WATER TURBINE DURING ABNORMAL OPERATION (SAFETY CLASS SYSTEM)

BOTH DRIVES ON SAME SHAFT

REHEATER REMOVES DECAY HEAT FROM FSV STEAM GENERATOR SERVING SAME FUNCTION AS CACS IN HTGR-SC/C REACTOR.

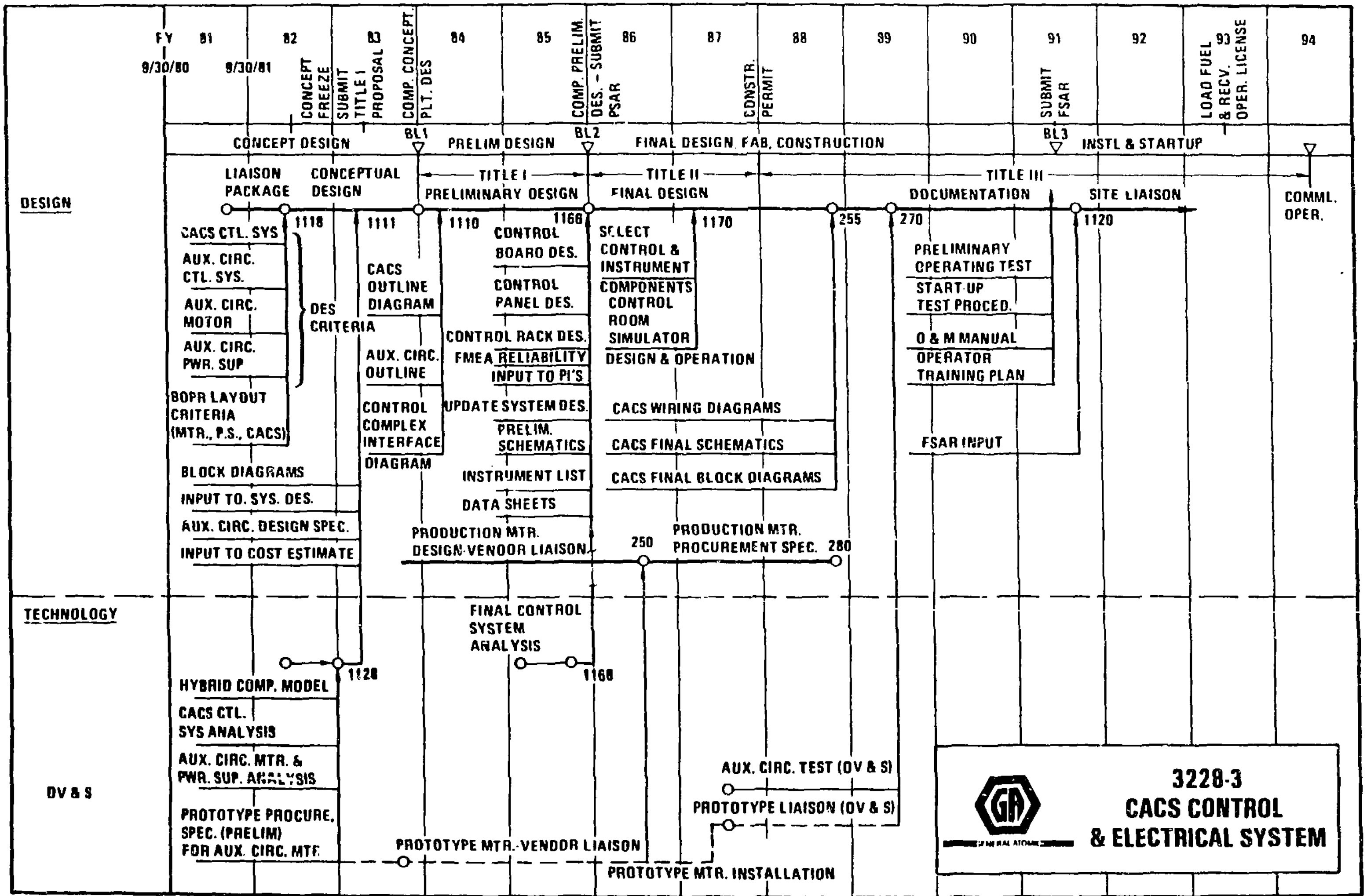
SINCE EMERGENCY HEAT REMOVAL SYSTEM FOR FSV IS DIFFERENT, DESIGN OF HTGR-SC/C DOES NOT HAVE DI-ECT FSV EXPERIENCE TO DRAW ON.

MOTOR & ELECTRICAL COMPONENTS ARE "OFF THE SHELF" AS MUCH AS POSSIBLE.

MOTOR IS IE & REQUIRES SEISMIC & ENVIRONMENTAL QUALIFICATION.

FSV PCRV COOLING WATER TEMP., PRESSURE & FLOW SCANNER DESIGN IS APPLICABLE.

F-870(2)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9/30/80
9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB, CONSTRUCTION
BL3
INSTL & STARTUP
DESIGN
LIAISON PACKAGE
CONCEPTUAL DESIGN
TITLE I
PRELIMINARY DESIGN
TITLE II
FINAL DESIGN
TITLE III
DOCUMENTATION
SITE LIAISON
COMML. OPER.
1118
1111
1110
1166
1170
255
270
1120
CACS CTL. SYS
AUX. CIRC. CTL. SYS.
AUX. CIRC. MOTOR
AUX. CIRC. PWR. SUP
DES CRITERIA
BOPR LAYOUT CRITERIA (MTR., P.S., CACS)
CACS OUTLINE DIAGRAM
AUX. CIRC. OUTLINE
CONTROL COMPLEX INTERFACE DIAGRAM
CONTROL BOARD DES.
CONTROL PANEL DES.
CONTROL RACK DES.
FMEA RELIABILITY INPUT TO PI'S
UPDATE SYSTEM DES.
PRELIM. SCHEMATICS
INSTRUMENT LIST
DATA SHEETS
SELECT CONTROL & INSTRUMENT COMPONENTS
CONTROL ROOM SIMULATOR DESIGN & OPERATION
CACS WIRING DIAGRAMS
CACS FINAL SCHEMATICS
CACS FINAL BLOCK DIAGRAMS
PRELIMINARY OPERATING TEST
START-UP TEST PROCED.
O & M MANUAL
OPERATOR TRAINING PLAN
FSAR INPUT
BLOCK DIAGRAMS
INPUT TO. SYS. DES.
AUX. CIRC. DESIGN SPEC.
INPUT TO COST ESTIMATE
PRODUCTION MTR. DESIGN-VENDOR LIAISON
250
PRODUCTION MTR. PROCUREMENT SPEC.
280
TECHNOLOGY
FINAL CONTROL SYSTEM ANALYSIS
1128
1168
HYBRID COMP. MODEL
CACS CTL. SYS ANALYSIS
AUX. CIRC. MTR. & PWR. SUP. ANALYSIS
DV & S
PROTOTYPE PROCURE. SPEC. (PRELIM) FOR AUX. CIRC. MTR.
PROTOTYPE MTR.-VENDOR LIAISON
AUX. CIRC. TEST (DV & S)
PROTOTYPE LIAISON (DV & S)
PROTOTYPE MTR. INSTALLATION
GA
3228-3
CACS CONTROL & ELECTRICAL SYSTEM

F-859(10)

6.12.4.6 MAJOR DOCUMENTS

CONCEPTUAL DESIGN (9/83)

DESIGN CRITERIA

CACS CONTROL SYSTEM

AUX. CIRC. MOTOR & POWER SUPPLY CONTROL SYSTEM

LAYOUT CRITERIA

CACS MOTOR & POWER SUPPLY

ANALYSIS

CACS CONTROL SYSTEM

DRAWINGS & DOCUMENTS

CACS BLOCK DIAGRAMS

AUX. CIRC. MOTOR & POWER SUPPLY FUNCTIONAL SPEC.

CACS CONTROL COMPLEX INTERFACE OUTLINE DIAGRAM – PRELIMINARY

PRELIMINARY DESIGN (9/85)

DRAWINGS

CONTROL BOARD DESIGN

SCHEMATIC DIAGRAM – PRELIMINARY

DOCUMENTS

INSTRUMENT LIST

INSTRUMENT DATA SHEETS – PRELIMINARY

FINAL DESIGN (9/88)

DESIGN REPORTS

CONTROL ROOM SIMULATION

DRAWINGS

CACS WIRING DIAGRAMS

SCHEMATIC DIAGRAMS – FINAL

BLOCK DIAGRAM – FINAL

DOCUMENTS

PRODUCTION CIRCULATOR MOTOR SPEC.

COMPONENTS

PROTOTYPE & PRODUCTION AUX. CIRC. MOTOR & POWER SUPPLY

INSTRUMENTATION BOARDS, RACKS & PANELS

AFTER 9/88

PRELIMINARY OPERATING TEST (POT)

START-UP TEST (SUT)

OPERATION & MAINTENANCE MANUAL (O&M)

OPERATOR TRAINING PLAN

DESIGN DATA NEEDS

GENERAL ATOMIC

ALL L1: PLANT LICENSEABLE UNDER EXISTING GROUND RULES.

DDN #	TITLE
2.28.2.4	VERIFY PERFORMANCE OF PROTOTYPE HARDWARE UNDER SIMULATED REACTOR CONDITIONS INCLUDING CIRCULATOR, VALVE, SERVICE SYSTEM, MOTOR, MOTOR CONTROL & ALL RELATED INSTRUMENTATION.

A96

A. CIRCULATOR : ΔP & LABYRINTH SEAL, SPEED INSTURENTS

B. VALVE: STATUS OF VALVE BY POSITION INSTRUMENTATION

C. SERVICE SYSTEM: BEARING AND SEAL MODULES INSTRUMENTATION

D. MOTOR, MOTOR CONTROL: POWER SUPPLY, INNERTER & CONTROLLOR

E. CACS CONTROL SYSTEM: VERIFY INTERACTION OF CACS CONTROL SYSTEM WITH PLANT PROTECTION (32) & OVERALL PLAN CONTROL (33).

CAPITOL COST IS INCLUDED IN THE CIRCULATOR TEST FACILITY (PRESENTED DURING AUXILIARY CIRCULATOR PRESENTATION)

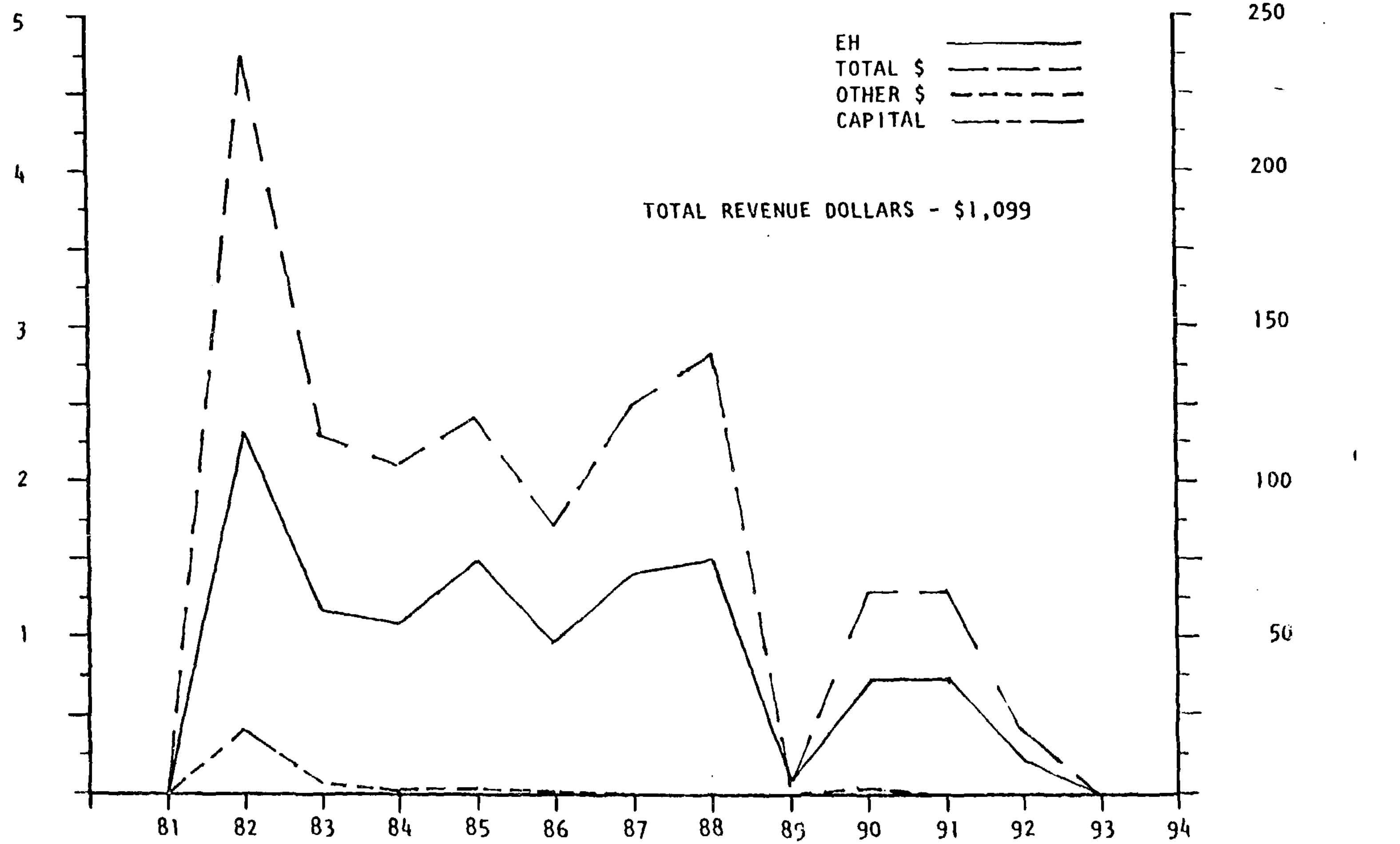
HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

GENERAL ATOMIC

EQUIVALENT HEADS (1824 HRS= 1 EQUIV. HD.)

SUBNET 3228-CORE AUX. COOLING SYSTEM , BAND CONTROL & ELECTRICAL

REVENUE DOLLARS (1981 $'S) NONESCALATED (000)



FISCAL YEAR

A97

NOTE: [illegible] NOT YET OPTIMIZED/L[illegible] LOADED

PART B

REACTOR SERVICE EQUIPMENT

PRESENTERS: J. K. Anderson (GA)
J. M. Krase (GA)

PART B

REACTOR SERVICE EQUIPMENT

The attendance and handouts for this presentation are attached at the end of these minutes for Part B of Session II.C.

I. INTRODUCTION AND REQUIREMENTS

John M. Krase made a brief introduction and presented the portion of the handouts relating to the items included in the reactor service equipment and the summary of the nuclear steam system (NSS) equipment costs for the lead plant.

II. CIRCULATOR HANDLING EQUIPMENT

John K. Anderson presented the portion of the handouts relating to the circulator handling equipment. This system handles both the main helium circulators and the auxiliary helium circulators and their isolation valves. The main circulator motor is handled by conventional methods using the containment crane. The circulators are handled with a double valved, shielded cask. The cask is, in turn, handled by the containment crane and a trailer transporter. The double valves separate, one to go with the cask to provide its closure and the other remains at the PCRV to prevent the ingress of air to the primary system.

Mr. Anderson's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - The cask is seismic category Class 1 because it must maintain the structural integrity of the pressure boundary for containment while mounted on the PCRV. The valves are of the gate type with inflatable seals.

2. V. Scotti - The shielding is only needed for the plateout on the circulator. The activation of circulator components is negligible.

3. L. Welshans - The cask has a self-contained cable hoist equipped with load cells. The required lift is seven feet.

4. V. Scott - Removal of the LIV and ALIV is a separate operation from removal of the circulator.

5. C. Forkel - The LIV and ALIV are separately mounted at their upper ends, not fastened to the circulators, so that they are not removed with the circulators.

6. L. Welshans - In response to the comment that inflatable seals at the Fast Flux Test Facility (FFTF) gave trouble on a 10 ft. diameter closure, they worked satisfactorily at FSV, although the closure was not as large.

III. STORAGE EQUIPMENT

John K. Anderson presented the portion of the handouts relating to the storage equipment. Control and orifice assemblies are stored in a vertical well in the service building. The well is provided with a shielded turntable to allow direct access to the upper part of the control assemblies for servicing. The handout sketch, No. F-882 (3), is incorrect in not showing the holes through the turntable to receive the control rod assemblies. The maintenance cycle on the control rod drives is eight years. One-eighth of the control rods will be in the service area at all times. Other items of reactor equipment, including in-vessel fuel handling equipment and helium circulators, are provided storage in gas tight wells in the service building.

Mr. Anderson's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. P. Kasten - The activity in the control rod storage well is controlled by the air handling system.

2. K. Van Howe - One-fourth of the core is refueled at a time.

3. K. Van Howe - The control and orifice assembly storage equipment is located in the reactor service building.

4. V. Scotti - The clearance of the reactor-to-reactor service building door is 26 ft. The circulator cask is not turned horizontal to pass this opening, but the auxiliary service cask and the fuel handling cask are turned horizontal.

5. V. Scotti - There is no requirement for a cask drop analysis because the casks are not lifted very far off the floor.

6. Unknown - The control rod storage wells will be maintained at negative pressure. It would be desirable to have controlled dry air in the well to prevent corrosion, but this is not being provided nor relied on. The drives are going to be designed and tested to be corrosion resistant to avoid corrosion problems that were encountered at FSV.

IV. REACTOR SERVICE FACILITY AND TOOLS

John K. Anderson presented the portion of the handouts relating to the reactor service facility and tools. The reactor equipment service facility will be used to perform remote maintenance on activated or contaminated equipment. It is of conventional mechanical design and is located in the reactor service building. The reactor equipment has undergone various changes and the FSV tools will no longer function with them. The tools will be redesigned as necessary to accommodate the final reactor component design. The master/slave manipulator was selected over a powered manipulator as a result of the FSV experience to obtain more flexibility.

The core service tools are used with the fuel handling machine. It is a powered manipulator which is used in conjunction with a TV camera.

The reserve shutdown system consists of a hopper filled with boronated graphite balls and a mechanism which will permit these balls to be released to dedicated channels in the core. The reserve shutdown vacuum tool is for the purpose of removing these balls from the core after an accidental trip or an emergency use of the system before returning the reactor to power. The system is essentially the same as the FSV unit except that it must be demonstrated to work with a core eight layers deep as well as with the six layer deep FSV core.

The core outlet temperature thermocouples must be replaced periodically. This is accomplished via flanged nozzles on the periphery of the PCRV. The thermocouple is first pulled manually until the part being exposed is too active to handle. Then, the core thermocouple service cask is connected to the remaining part of the thermocouple which then wound into the cask for removal and disposal.

Mr. Anderson's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - The reactor equipment service facility provides for the checkout and maintenance of the fuel handling equipment that has become contaminated. The facility may become contaminated, but it is intended that the facility will be clean most of the time.

2. Unknown - The grapple of the fuel handling machine may very well become contaminated in use. It would not be cleaned while refueling.

3. V. Scotti - There are two manipulators. They do not cover the full range of the facility. The tools that will be needed will be located within reach of the manipulators. Others will be located in a rack transported by the crane to bring them within reach. Mr. Scotti remained of the opinion that the manipulators should cover the full range of the facility.

4. V. Scotti - It is intended to provide the circulator cask with sprays that can be used to decon the impeller for contact inspection or servicing.

5. V. Scotti - Fuel elements will not normally be brought into the reactor service facility, but the capability is required in the case of an accident.

6. F. Swart - There is no intention to service the circulators at the plant other than visual inspection. The philosophy has been to do no more maintenance operations at the site than necessary.

7. V. Scotti - The reserve shutdown vacuum tool was successfully used a couple of times at FSV.

8. M. Brown - The holes in the core that receive the reserve shutdown balls are located at the side of the control fuel elements.

9. L. Welshans - The Class I seismic category for the core thermocouple service cask is in error.

10. V. Scotti - The ISI on the core outlet thermocouple flanged nozzle is by monitoring the pressure in the space between the double O-ring seals.

V. WIRE WINDING MACHINE (WWM)

John K. Anderson presented the portion of the handouts relating to the WWM. The WWM is a GA patented device for the purpose of winding the circumferential reinforcement cables around the PCRV during construction. It travels around the PCRV applying the cable under tension as it goes. The performance of the tensioning device must be qualified. The WWM applies the 1/2-inch, 7-strand cable at the rate of 300 ft/min. at a stress of 30,000 psi. The cable is applied in a continuous wrap of 53 turns in each layer in each groove for a total one-piece length of 17,000 ft. Each layer is anchored at the top of the groove, the cable is wound, and again anchored at the bottom of the groove. There are a total of 487 layers of cable with a maximum of 14 layers per groove.

Mr. Anderson's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. C. Forkel - A "layer" is one continuous wrap between anchored ends in one groove. The 487 layers are distributed over 25 grooves. The maximum number of layers per groove is 14; the grooves at the top of the PCRV do not need the maximum number of layers.

2. Unknown - The WWM is attached to the PCRV by two large rubberized conveyor belts that completely surround the PCRV. The WWM pulls itself around the PCRV by means of these belts.

3. Unknown - For ISI, there are a series of cable load monitors within the PCRV system.

4. C. Dupen - The grippers of the cable stretcher stay in place on the cable by a system of belville washers so that the cable is progressively stretched with very little indentation and no scraping.

VI. DESIGN AND TECHNOLOGY PLANS

John M. Krase presented the portion of the handouts relating to the design and technology plans. The mechanical technology work breakdown structure of viewgraph No. 3216 will support the ISI system requirements work to conform to ASME Code Section XI. From the mechanical equipment standpoint, there will be surveys of available equipment in response to the requirements and the development of a special design for the ISI equipment. The mechanical design technology activities will provide input to the conceptual design of the ISI equipment to demonstrate feasibility. A FSV experience carryover report will be prepared during FY-1982.

The WWM will be checked out for function and reliability on a test ring of size comparable to the PCRV. The cost of the WWM tests is $1,045K, including $630K for capital facility but excluding the cost of the WWM fabrication. There will be a temporary wooden mock-up of the reactor service facility built for checkout of the tools.

The reserve shutdown vacuum tool will be demonstrated in a helium filled autoclave facility; it is erroneously indicated in the DWN document as being tested in air. The purpose is to reduce the technical risk on its performance.

The reactor service tools will be tested in a facility mock-up for the purpose of risk reduction. The facility may be located in any industrial building having enough headroom (about 50 ft.) and floor space.

In the cost summary, the $6.54M design plan costs include the detail engineering and the manufacturing drawings for the equipment. The $0.63M cost of capital equipment included in the technology plan cost is for the WWM test ring. The vendor only builds the NSS equipment.

Mr. Krase's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. M. Brown - The slack time on viewgraph 3216 is not for the correction of unforeseen difficulties with the WWM, but rather because as a matter of policy all schedules are based on an early start.

2. C. Forkel - The WWM is being developed at this time because there was no such machine used at FSV. The circumferential reinforcing cables at FSV are actually linear tendons instead of a continuous wire wrap.

3. Unknown - The $50K cost of the core outlet thermocouple service tool test does not include the cask. The estimated cost of the cask is an additional amount about equal to the test cost.

4. P. Kasten - The reserve shutdown vacuum tool will be tested in helium instead of air to avoid a fluid dynamical argument over the different flow characteristics of air and helium. The test on the FSV machine was done in helium and was satisfying to all parties.

This concludes the minutes for Part B.

HTGR
DESIGN REVIEW
SESSION II C
12/9/81

NAME	ORGANIZATION
MIKE NICHOLS	GA
JOHN KRASE	GA
DAVE KAPICH	GA
Fred Swart	GCRA
CHARLIE BOLAND	GA
Vincent G. Scotti	CE
CLIVE DUPEN	C-E
PAUL KASTEN	ORNL
STAN BROWN	GAC
L M Welshans	DOE
A.T. Goodjohn	GAC
JOHN PICCOLO	EG&G
JOHN ANDERSON	GA
DON GIEGLER	GA
CARMELO RODRIGUEZ	GA
K.R. VAN HOWE	SMSC
Robert F. Stearns	Bechtel
R. A. Evans	GCRA
MERWIN BROWN	ARIZ. P&B SER. CO.
CURT E. FORKEL	EG&G

HTGR REACTOR SERVICE EQUIPMENT

B10

GENERAL ATOMIC COMPANY

REACTOR SERVICE EQUIPMENT
(SYSTEM 16)

INCLUDES THE FOLLOWING ITEMS:

- Circulator Handling Equipment
- Core Outlet Thermocouple Service Equipment
- Core Service Tools
- Reactor Service Facility Tools
- Control and Orifice Assembly Storage Equipment
- Equipment Storage Wells
- Wire Winding Machine
- In-Service-Inspection Equipment Feasibility (BOP Eqpt.)

GENERAL ATOMIC

REACTOR SERVICE EQUIPMENT
(SYSTEM 16)

SUMMARY - LEAD PLANT NSS DIRECT PRICE (Millions, 1 January 1981 Dollars)

	Price	NSS Category
- Circulator Handling Equipment	1.31	O&M Eqpt.
- Core Outlet Thermocouple Service Equipment	.06	O&M Eqpt.
- Core Service Tools	.37	O&M Eqpt.
- Reactor Service Facility Tools	.86	O&M Eqpt.
- Control and Orifice Assembly Storage Equipment	.63	Base Scope
- Wire Winding Machine	3.31	Leased
SUM - NSS PRICES	6.54	

CIRCULATOR HANDLING EQUIPMENT

FUNCTION

Remove and replace main helium circulators, auxiliary helium circulators and loop isolation valves; shield these components and transport them on-site.

HANDLING CONCEPT

Motor handled by conventional methods with containment crane.

Circulator handled by shielded cask with double valves.

REQUIREMENTS

Safety Class: 3 for primary boundary components, NN for the balance

Quality Assurance Level: II

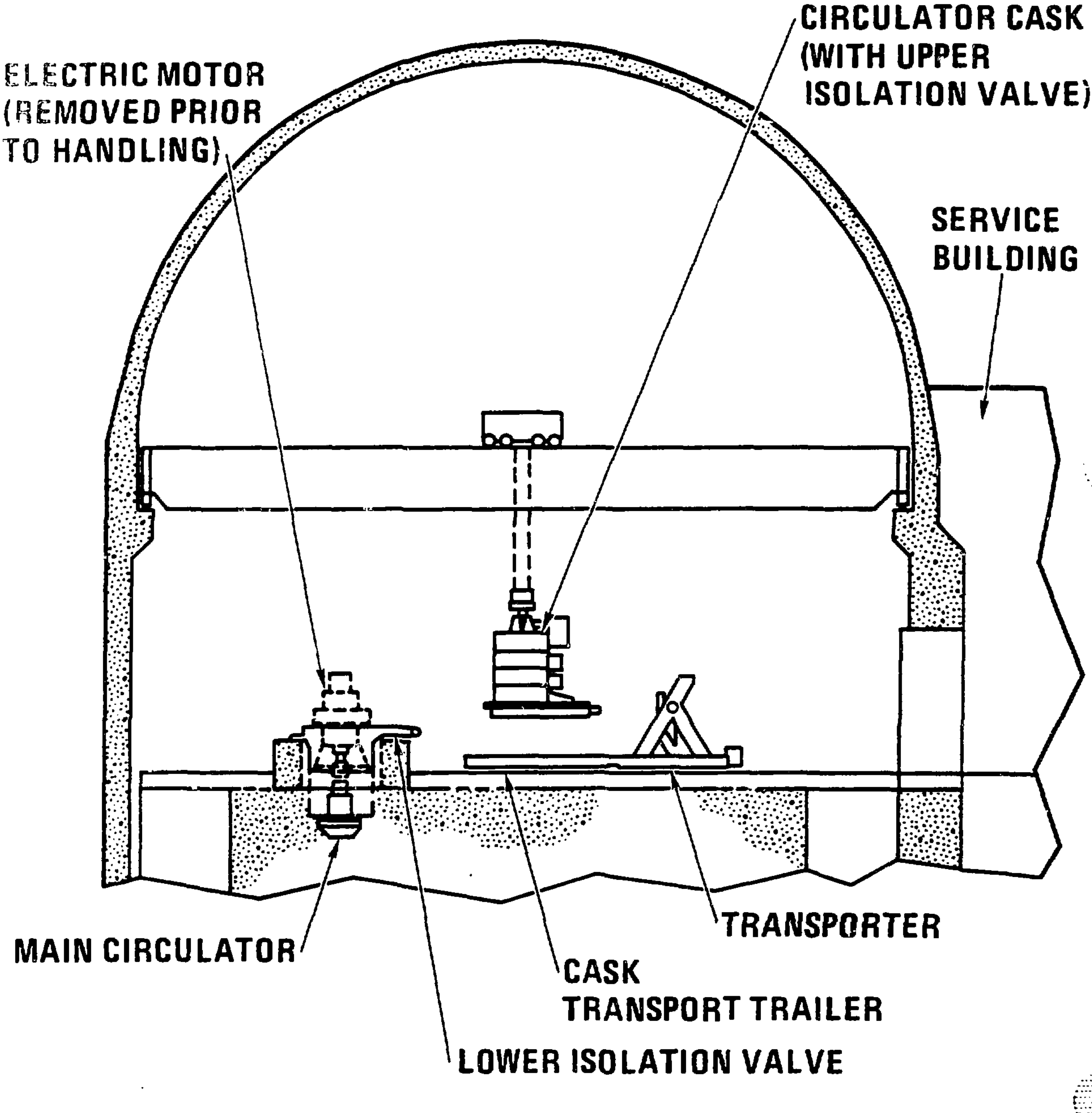
Design Code: ASME Sec. III Div. 1 Class 3 for primary boundary components; conventional mechanical design for the balance

Seismic Category: I

10 CFR50 Appendix B: Applicable

GENERAL ATOMIC

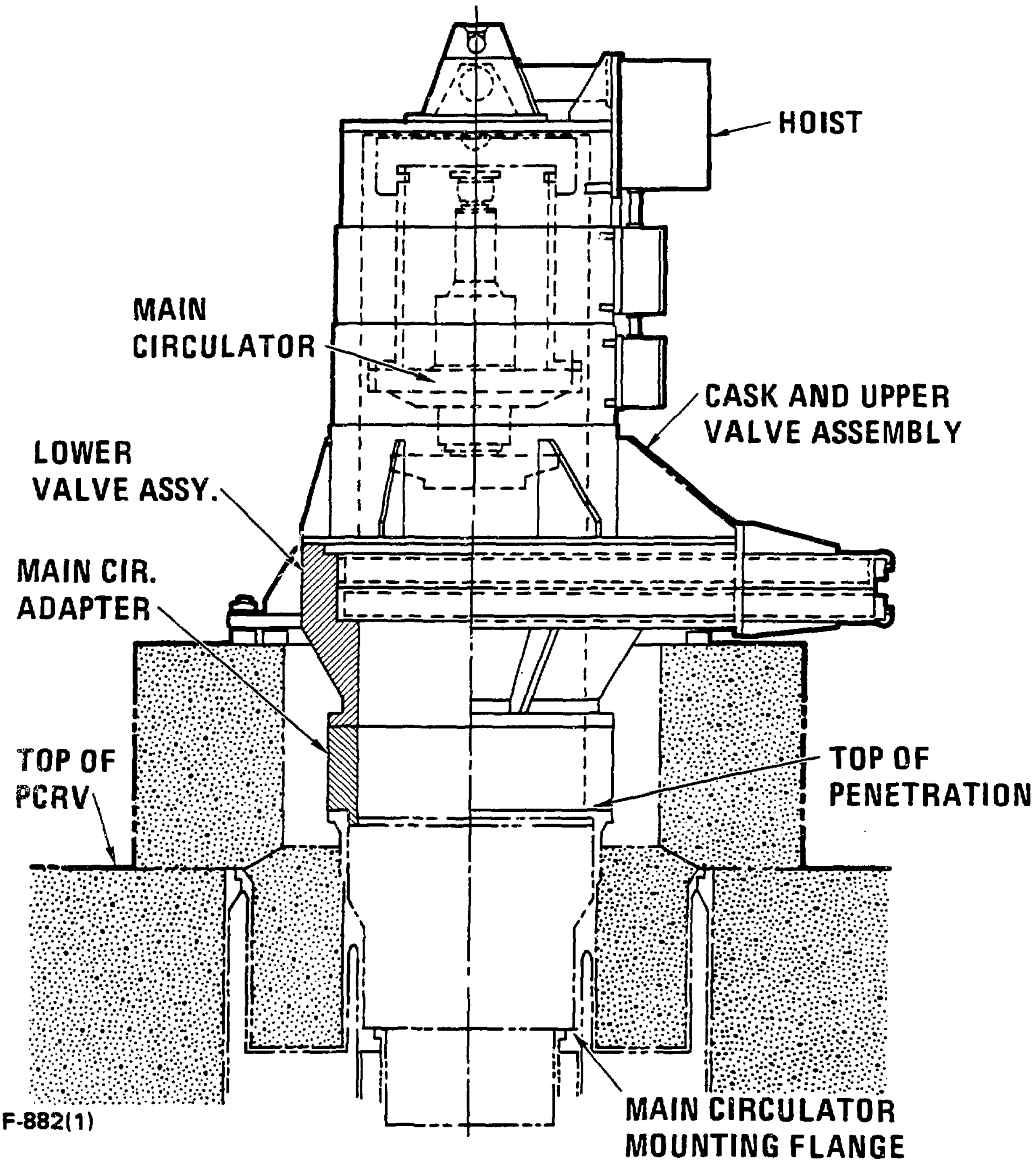
CIRCULATOR HANDLING CONCEPT



F-882(7)

GENERAL ATOMIC

CIRCULATOR HANDLING EQUIPMENT



F-882(1)

CONTROL AND ORIFICE ASSEMBLY STORAGE EQUIPMENT

FUNCTION

Storage of control and orifice assemblies (temporarily removed during refueling, or removed for service, or new/serviced assemblies awaiting installation).

Temporary storage of shield plugs removed from reactor of spent filter/adsorber units, or reserve shutdown vacuum tool.

STORAGE CONCEPT

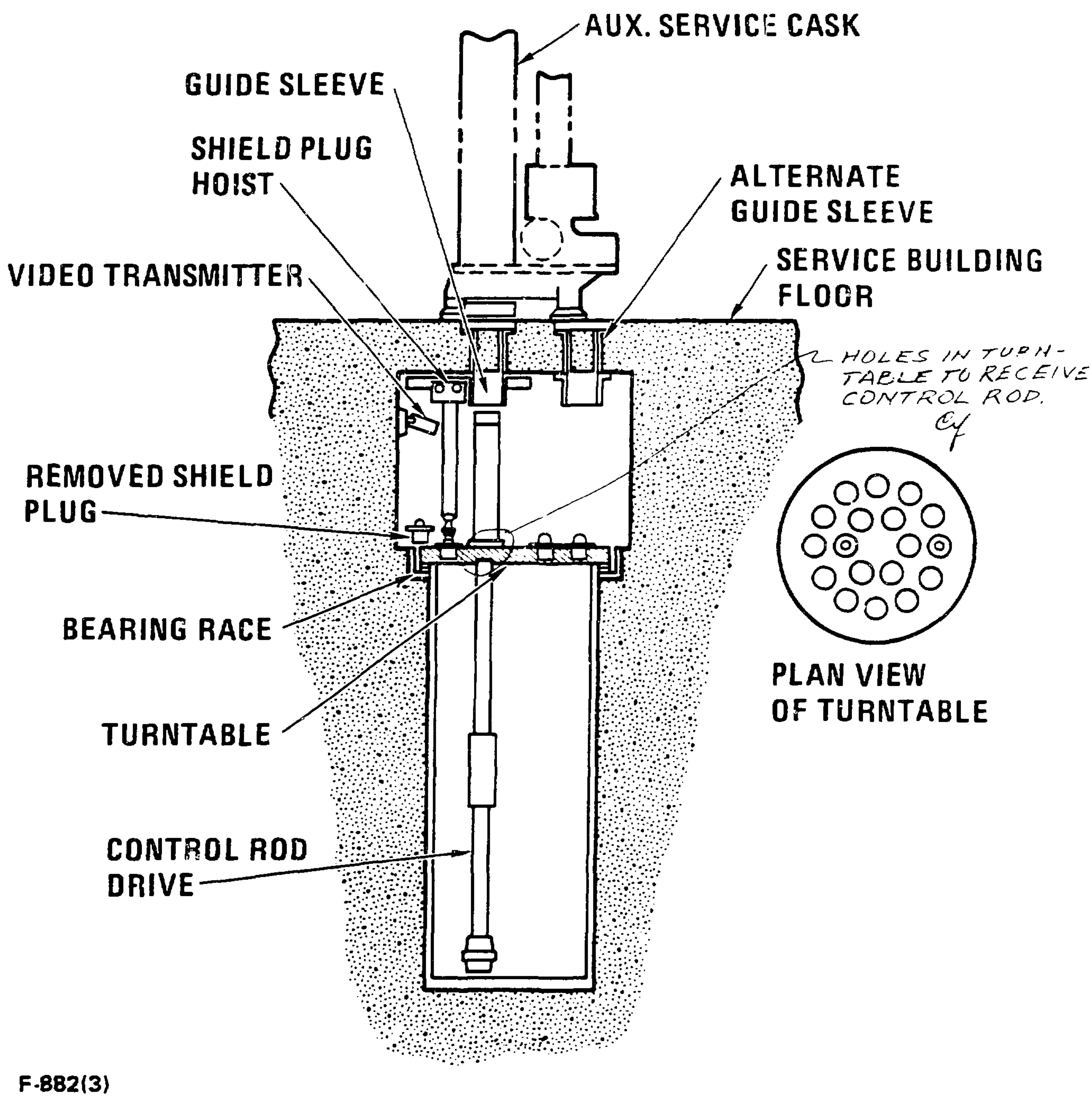
Vertical well in service building, with 18 storage locations in turntable.

Shielding on turntable allows service operations on upper portion of assembly.

REQUIREMENTS

Conventional mechanical design. No requirements imposed by Safety Classification, Quality Assurance, Design Codes, Seismic Classification, or 10 CFR50.

CONTROL AND ORIFICE ASSEMBLY STORAGE EQUIPMENT



F-882(3)

EQUIPMENT STORAGE WELLS

FUNCTION

Store in-vessel fuel handling equipment, helium circulators, and other reactor equipment that may become activated or contaminated.

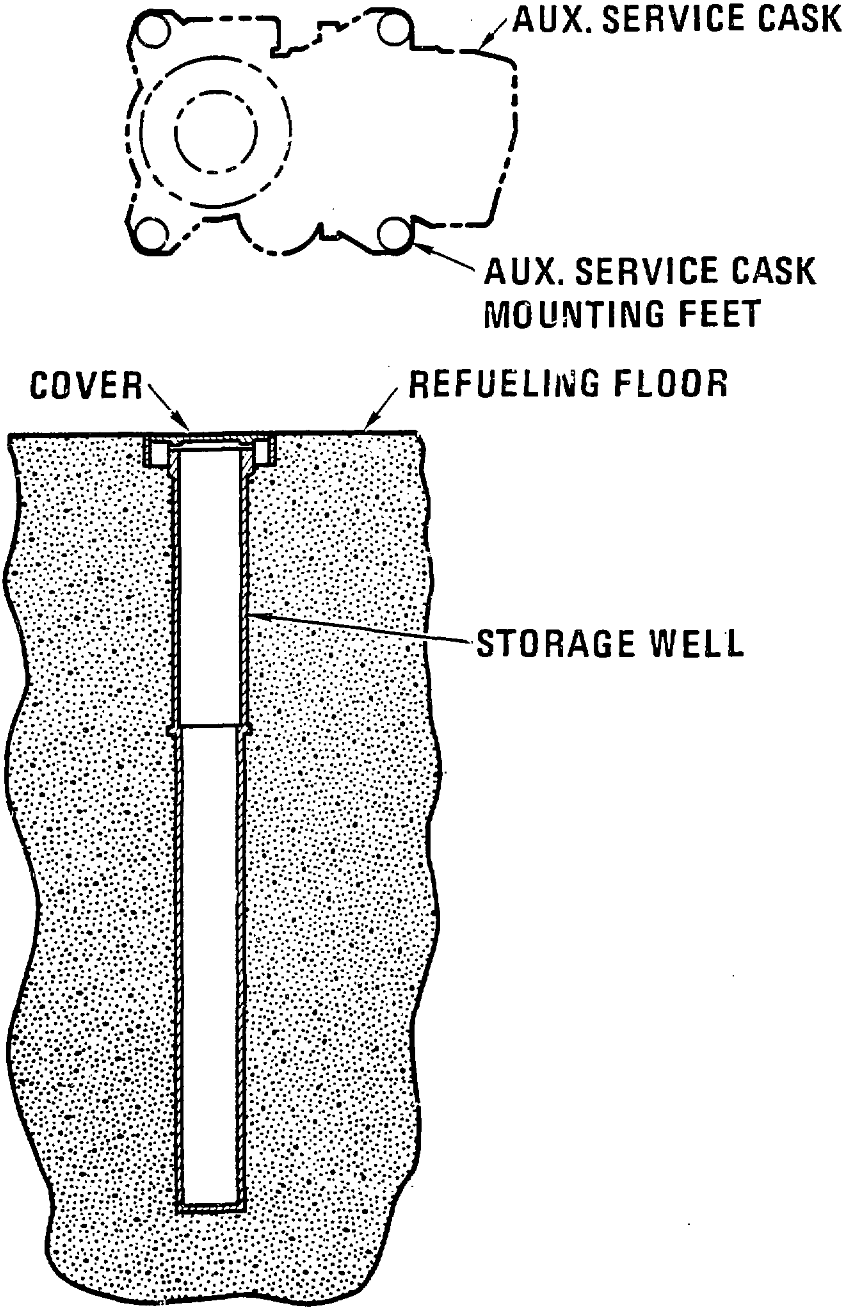
STORAGE CONCEPT

Gas-tight wells in service building with shielded covers.

REQUIREMENTS

Safety Class: NN
Quality Assurance Level: III
Design Code: ASME Sec. VIII
Seismic Category: NA
10 CFR50 Appendix B: Not Applicable

PLENUM TRANSPORTER STORAGE WELL



F-882(9)

REACTOR SERVICE FACILITY TOOLS

FUNCTION

Perform remote maintenance tasks on activated or contaminated NSS equipment, within the shielded service facility (BOP).

SERVICE CONCEPT

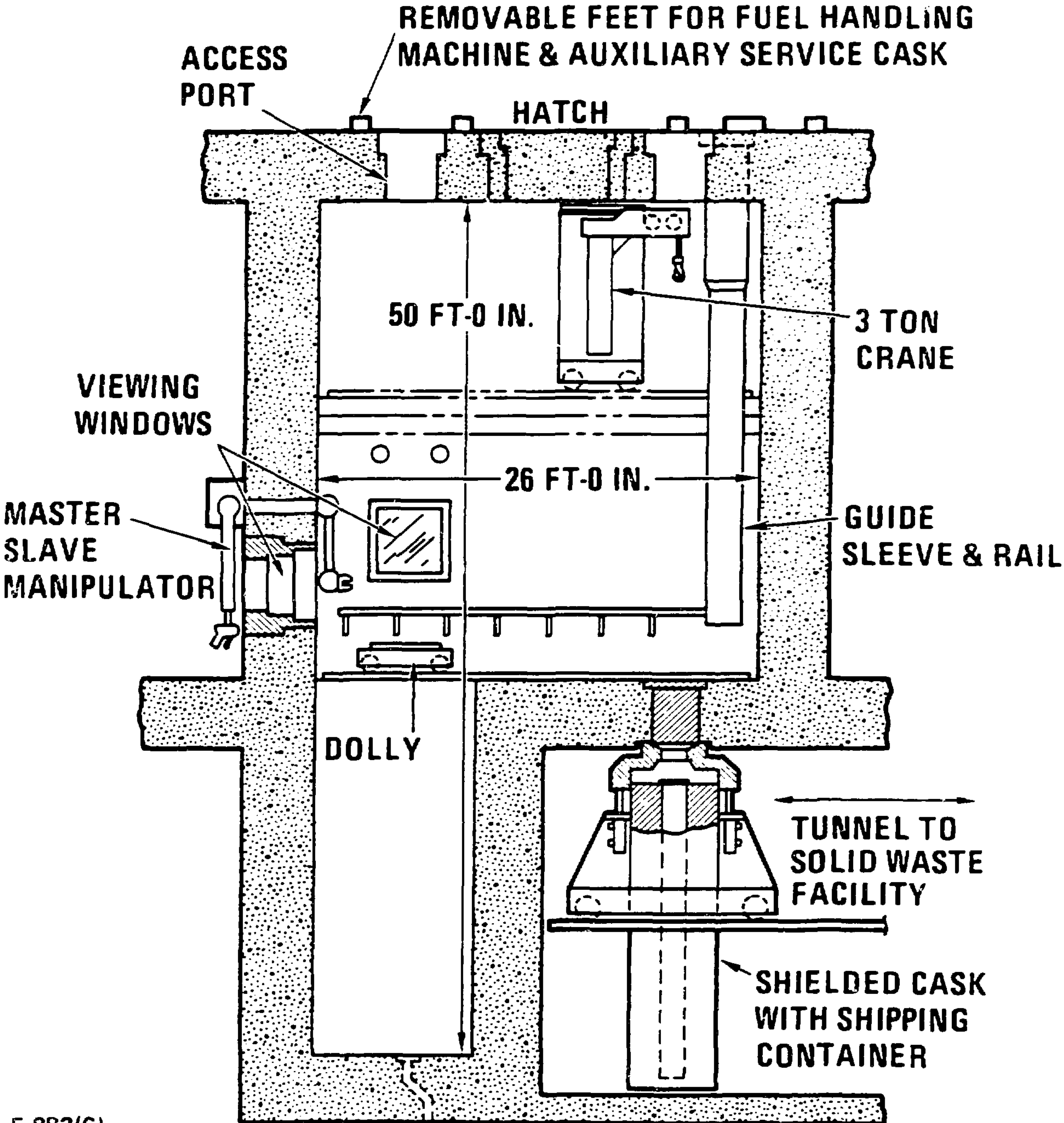
Remotely handled tools falling into three main categories:

- Positioning tools which place the part to be serviced within manipulator reach and viewing area of facility windows
- Fixturing equipment which hold parts in place during servicing operations
- Special purpose tooling used in conjunction with manipulators to perform specific tasks

REQUIREMENTS

Conventional mechanical design. No requirements imposed by Safety Classification, Quality Assurance, Design Codes, Seismic Classification, or 10 CFR50.

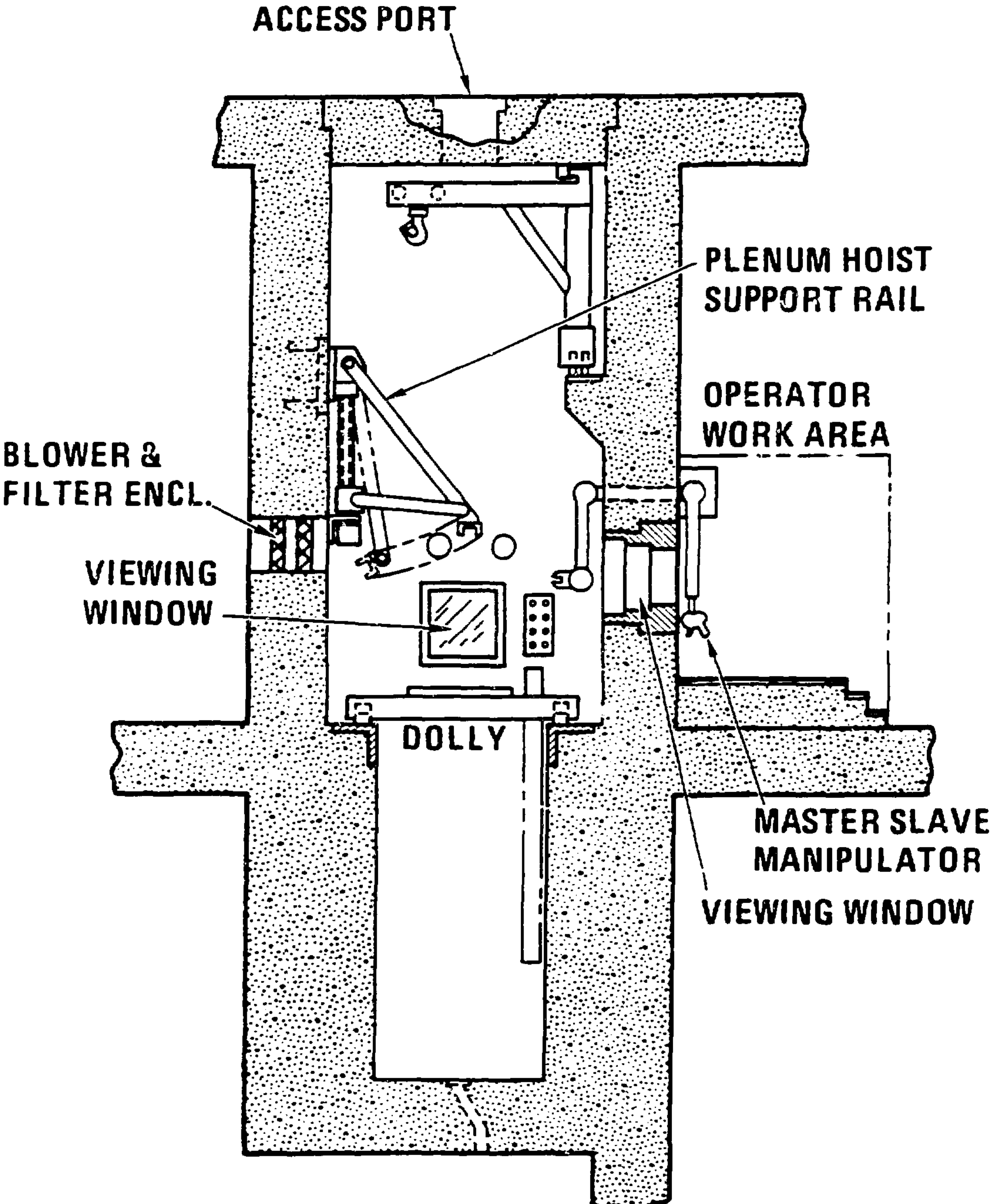
REACTOR EQUIPMENT SERVICE FACILITY



F-882(6)

GENERAL ATOMIC

REACTOR EQUIPMENT SERVICE FACILITY



F-882(5)

CORE SERVICE TOOLS

FUNCTION

Perform remotely-operated core service and maintenance.

SERVICE CONCEPT

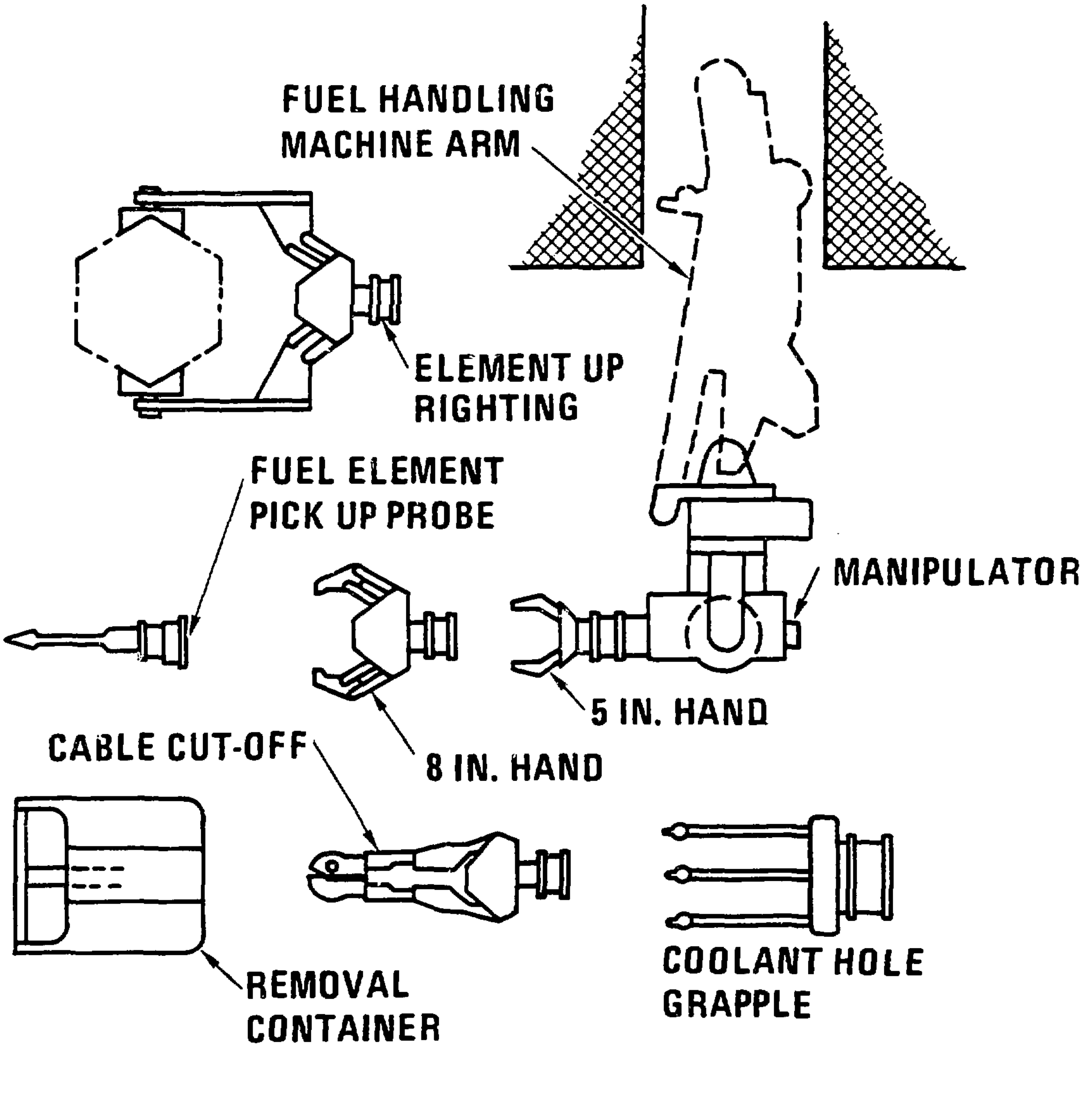
Manipulator and special tools mounted on the fuel handling machine arm, used in conjunction with remote viewing camera (Syst. 13).

Vacuum device mounted on auxiliary service cask for removal of discharged reserve shutdown material.

REQUIREMENTS

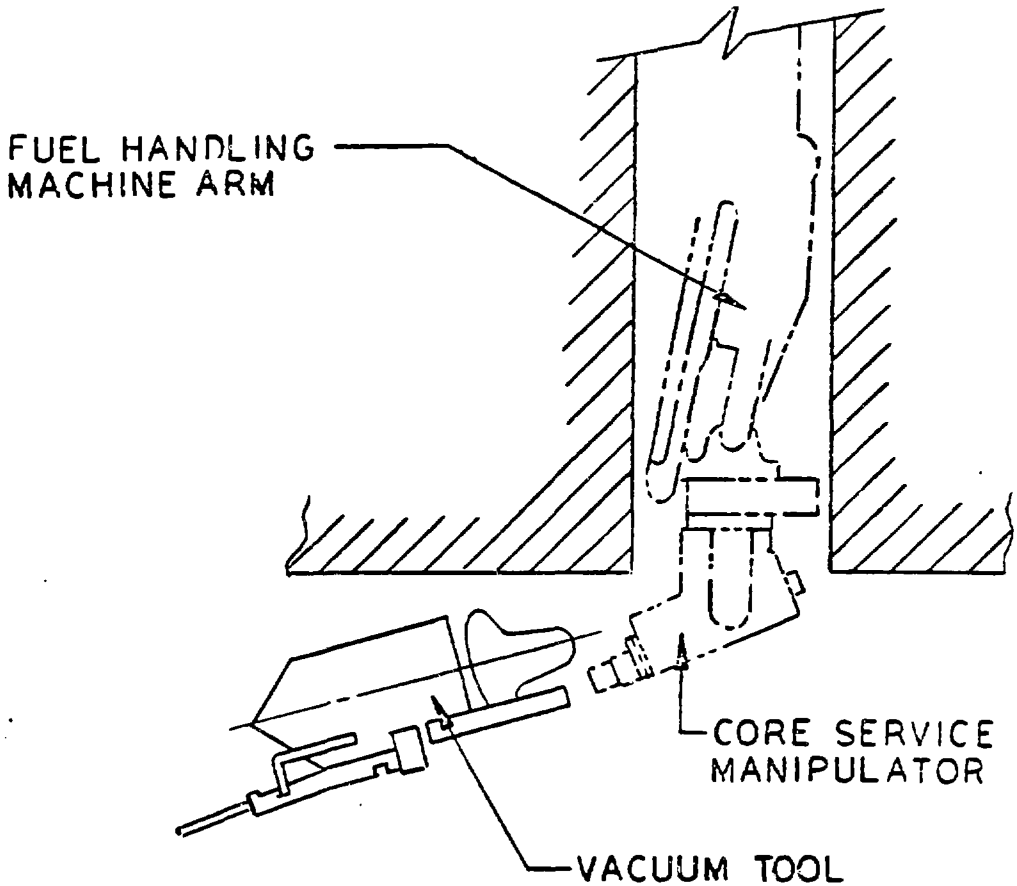
Conventional mechanical design. No requirements imposed by Safety Classification, Quality Assurance, Design Codes, Seismic Classification, or 10 CFR50.

CORE SERVICE MANIPULATOR & TOOLS



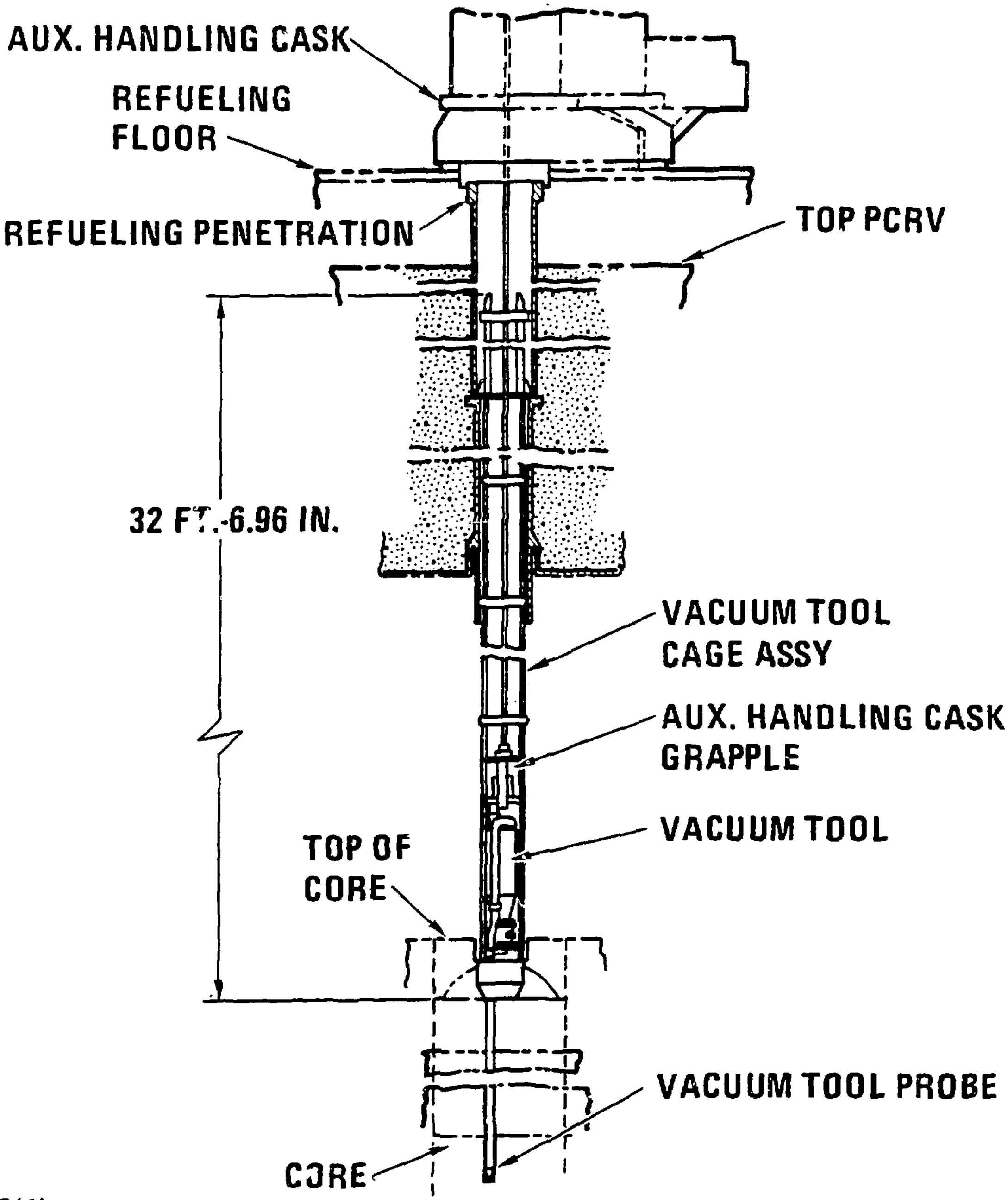
F-882(8)

CORE SERVICE VACUUM TOOL



RESERVE SHUTDOWN VACUUM TOOL

GENERAL ATOMIC



F-882(4)

CORE OUTLET THERMOCOUPLE SERVICE EQUIPMENT

FUNCTION

Remove core region outlet thermocouples.

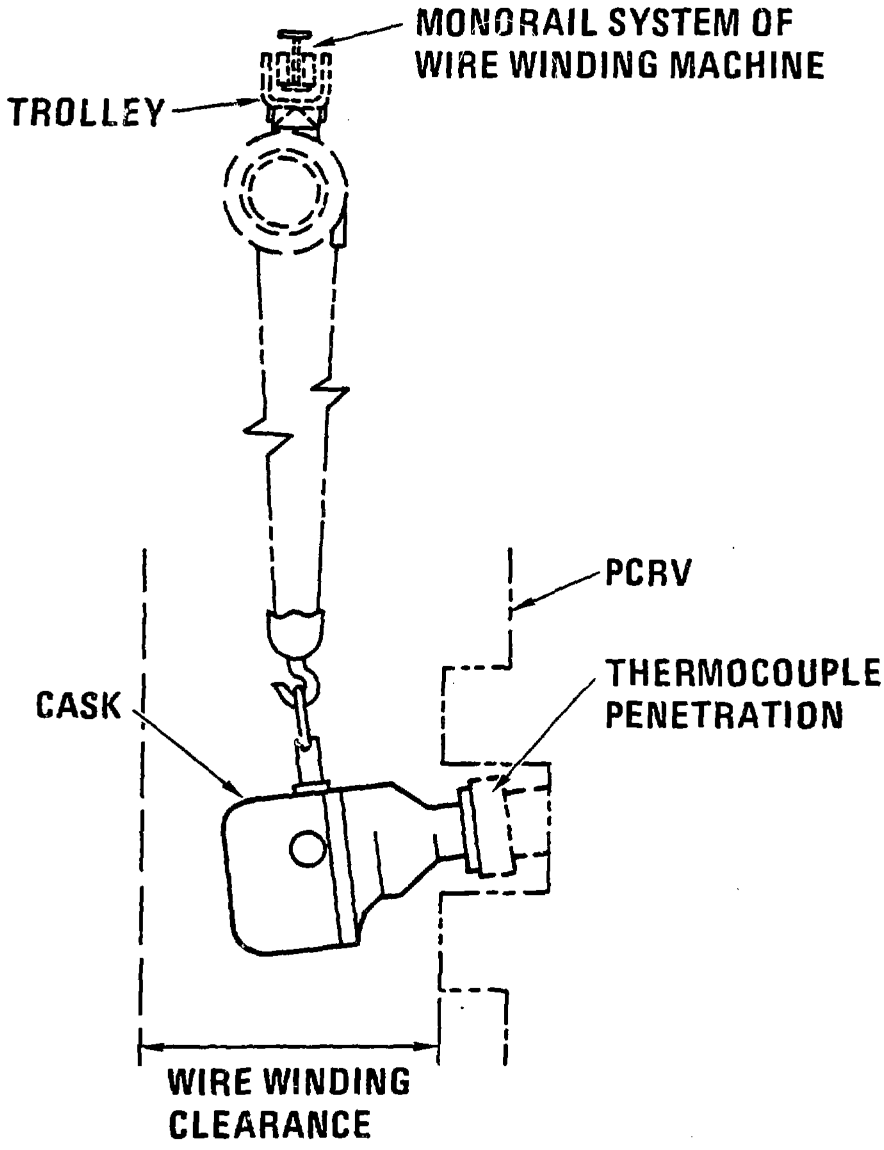
SERVICE CONCEPT

Thermocouple pulled into shielded cask and cut into sections. Fresh thermocouples installed manually.

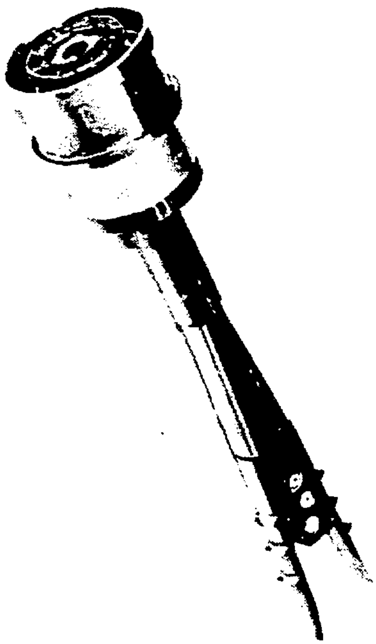
REQUIREMENTS

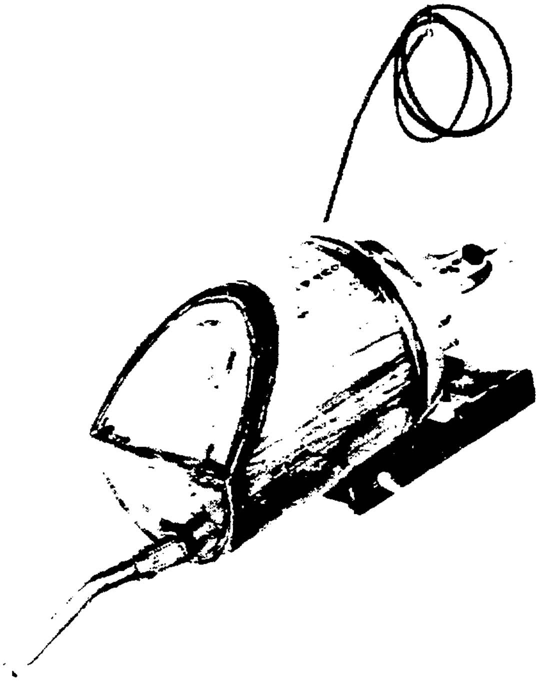
Safety Class: 3
Quality Assurance Level: III
Design Code: None applicable (conventional mechanical design)
Seismic Category: I
10 CFR50 Appendix B: Applicable

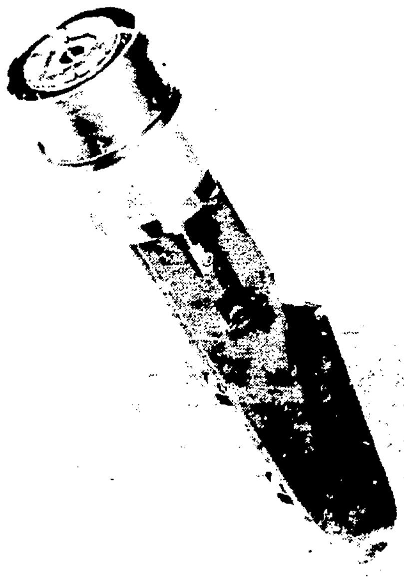
CORE THERMOCOUPLE SERVICE EQUIPMENT



F-882(2)







WIRE WINDING MACHINE

FUNCTION

Install reactor vessel circumferential prestressing strand.

OPERATION CONCEPT

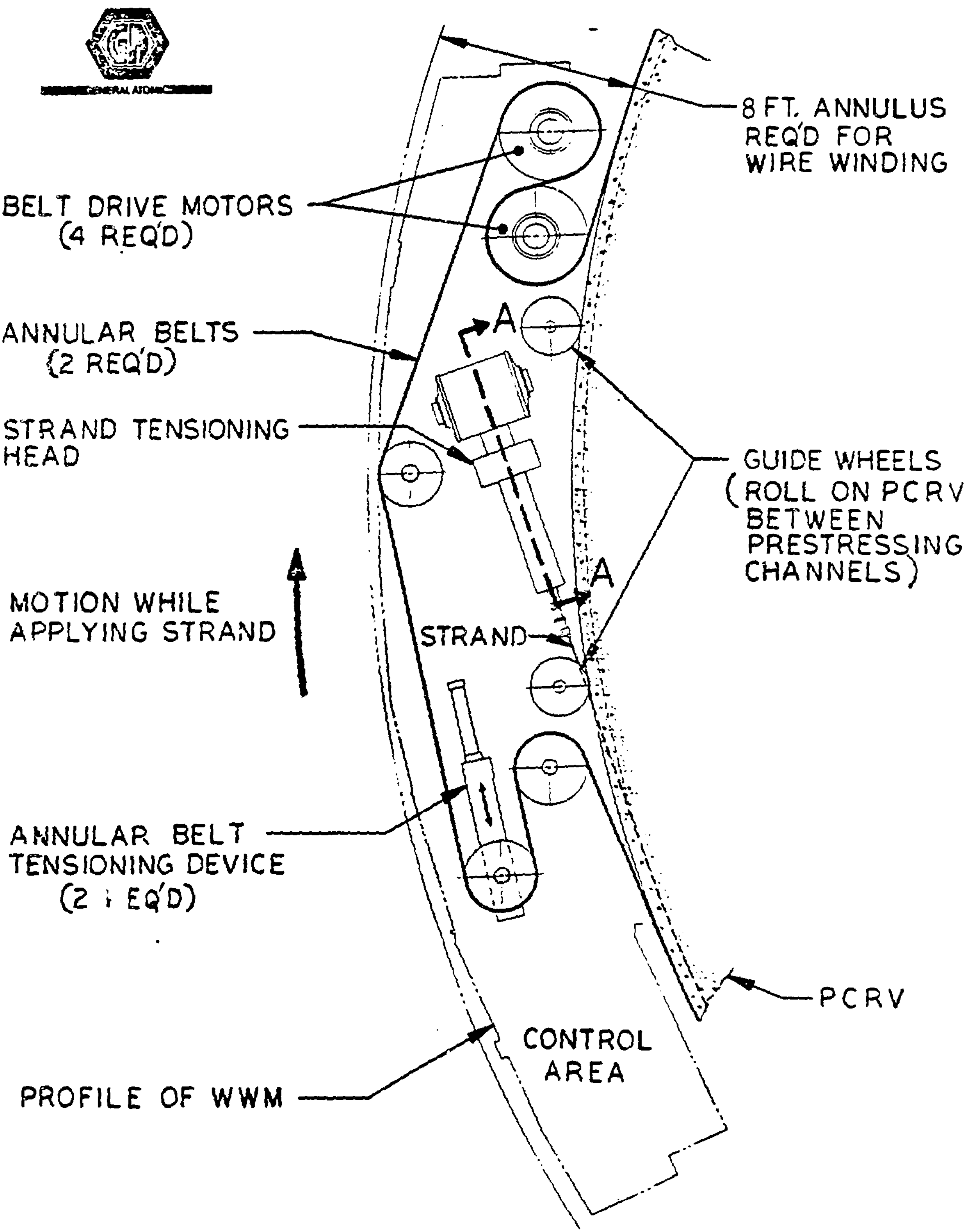
Machine revolving around PCRV on wheels while suspended from a monorail.

Steel-reinforced rubber belts pull the machine against the PCRV.

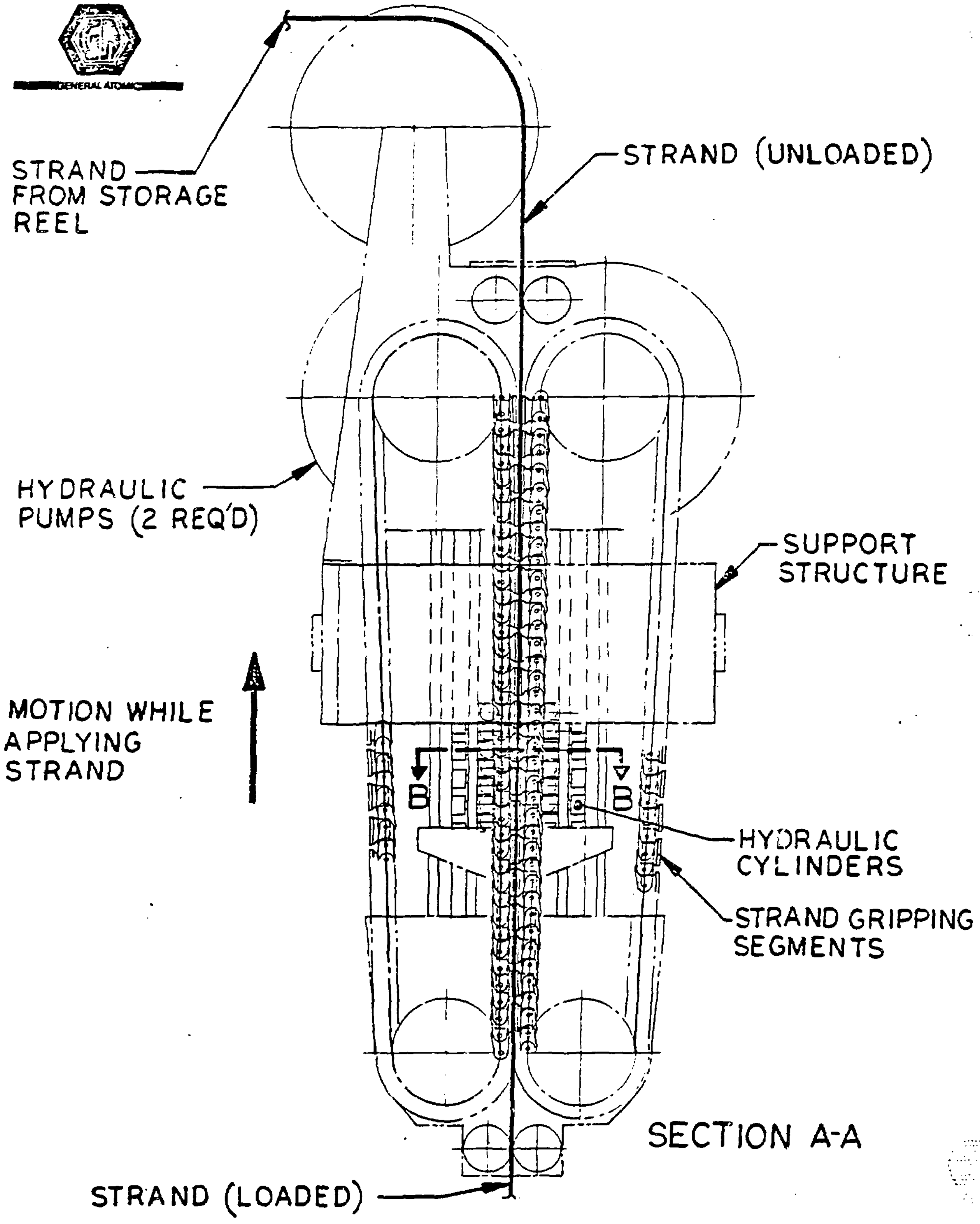
Hydraulic systems tension the belts, drive the machine, and tension the strand being installed.

REQUIREMENTS

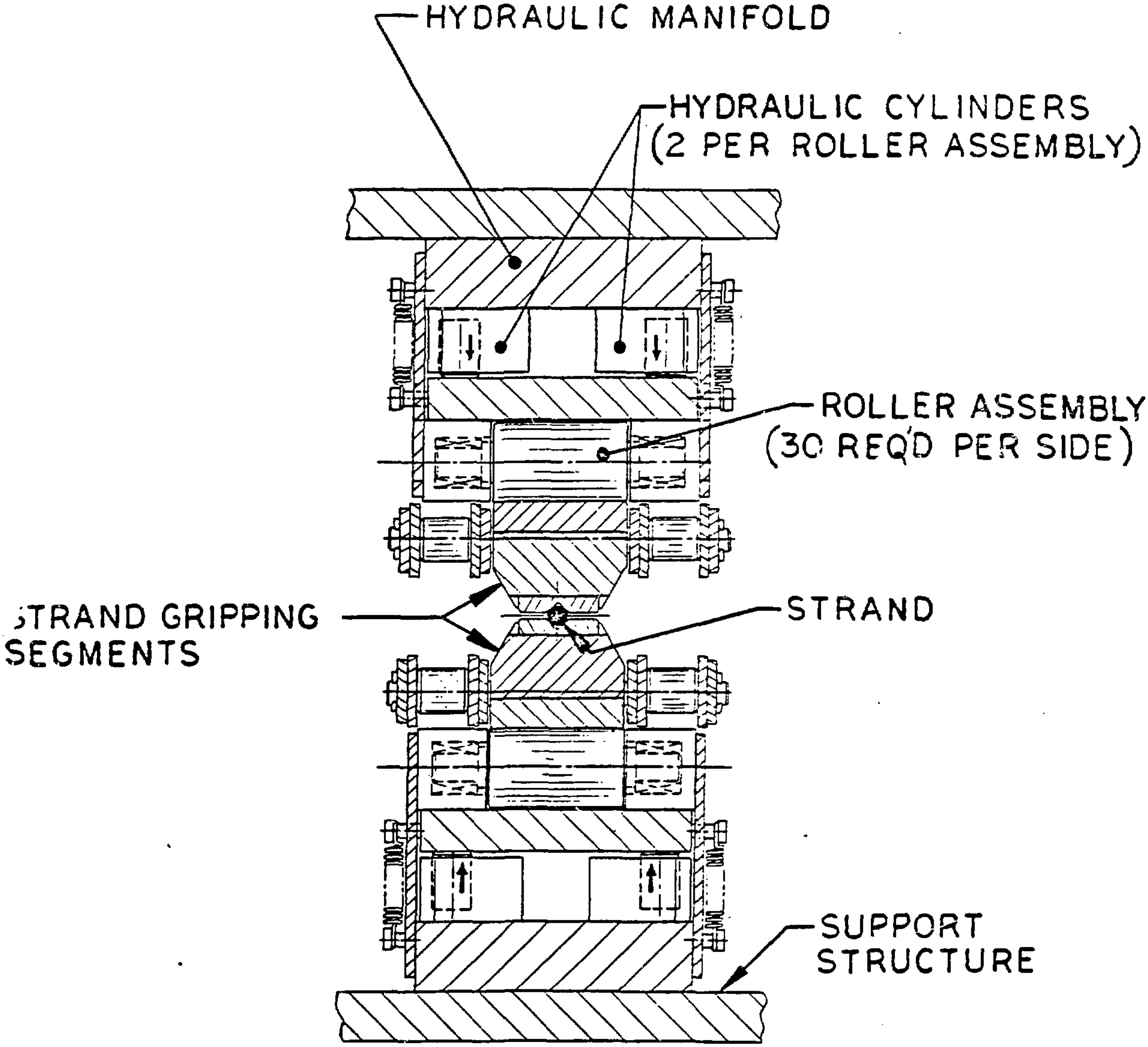
Safety Class: NN
Quality Assurance Level: NA
Design Code: NA (conventional mechanical design)
Seismic Category: NA
10 CFR50 Appendix B: NA



PLAN VIEW OF WIRE WINDING MACHINE



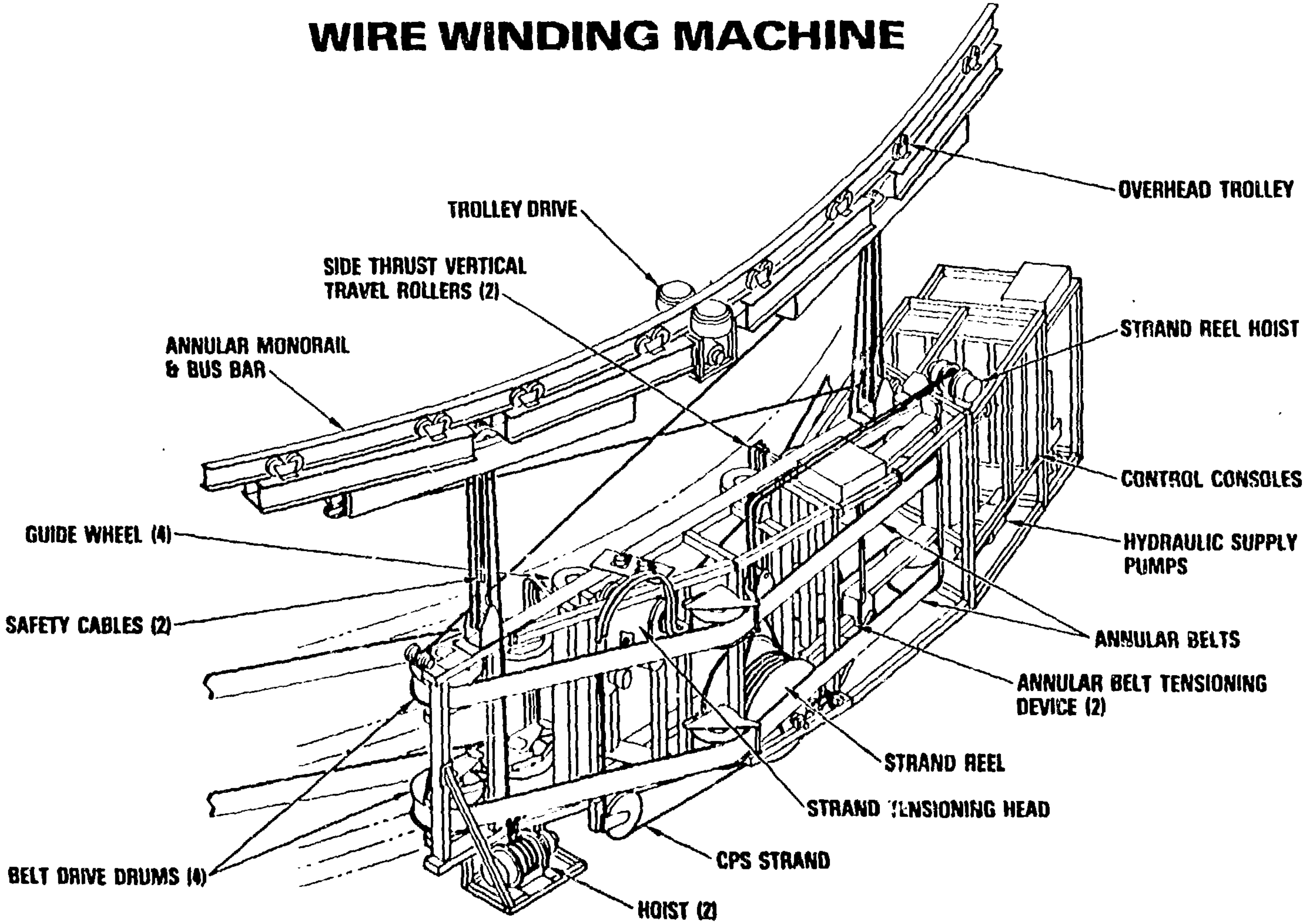
STRAND TENSIONING HEAD – WWM



SECTION B-B

STRAND TENSIONING HEAD - WWM

WIRE WINDING MACHINE



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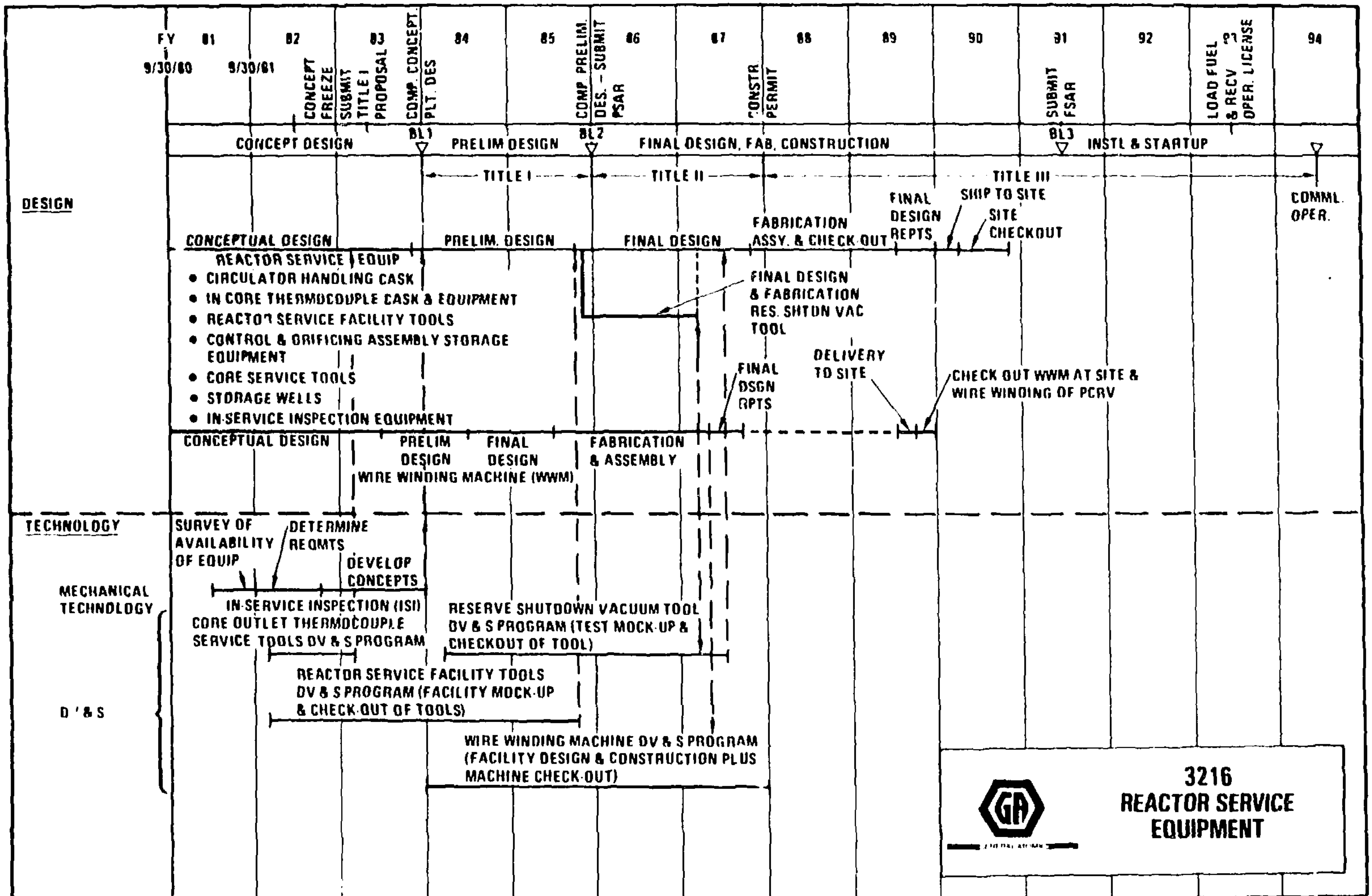

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CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR PERMIT
SUBMIT FSAR
LOAD FUEL & RECV OPER. LICENSE
BL1
BL2
BL3
CONCEPT DESIGN
PRELIM DESIGN
FINAL DESIGN, FAB, CONSTRUCTION
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
COMML. OPER.
DESIGN
CONCEPTUAL DESIGN
PRELIM. DESIGN
FINAL DESIGN
FABRICATION ASSY. & CHECK OUT
FINAL DESIGN REPTS
SHIP TO SITE
SITE CHECKOUT
REACTOR SERVICE EQUIP
• CIRCULATOR HANDLING CASK
• IN CORE THERMOCOUPLE CASK & EQUIPMENT
• REACTOR SERVICE FACILITY TOOLS
• CONTROL & ORIFICING ASSEMBLY STORAGE EQUIPMENT
• CORE SERVICE TOOLS
• STORAGE WELLS
• IN-SERVICE INSPECTION EQUIPMENT
FINAL DESIGN & FABRICATION RES. SHTDN VAC TOOL
FINAL DSGN RPTS
DELIVERY TO SITE
CHECK OUT WWM AT SITE & WIRE WINDING OF PCRV
CONCEPTUAL DESIGN
PRELIM DESIGN
FINAL DESIGN
FABRICATION & ASSEMBLY
WIRE WINDING MACHINE (WWM)
TECHNOLOGY
SURVEY OF AVAILABILITY OF EQUIP
DETERMINE REQMTS
DEVELOP CONCEPTS
MECHANICAL TECHNOLOGY
IN-SERVICE INSPECTION (ISI) CORE OUTLET THERMOCOUPLE SERVICE TOOLS DV & S PROGRAM
RESERVE SHUTDOWN VACUUM TOOL DV & S PROGRAM (TEST MOCK-UP & CHECKOUT OF TOOL)
D'& S
REACTOR SERVICE FACILITY TOOLS DV & S PROGRAM (FACILITY MOCK-UP & CHECK-OUT OF TOOLS)
WIRE WINDING MACHINE DV & S PROGRAM (FACILITY DESIGN & CONSTRUCTION PLUS MACHINE CHECK-OUT)
3216
REACTOR SERVICE EQUIPMENT

F 859(1)

REACTOR SERVICE EQUIPMENT - SYSTEM 16

OVERALL DESIGN & TECHNOLOGY STATUS

- Service Operations to be performed have been identified (based upon large HTGR and FSV programs)
- Servicing philosophy has been developed
- Service equipment concepts have been established
- Equipment envelopes have been determined to the extent required for plant layout
- Conceptual design & requirements documentation have been initiated (FY'82)
- FSV Experience Carryover Report is in preparation (FY'82)

GENERAL ATOMICS

WIRE WINDING MACHINE

FUNCTIONAL & RELIABILITY TESTS

DDN	DESCRIPTION
2.16.D.2	* - Functional performance test yields from parameters for final design PCRV prestressing * - Facility full size test ring with multiple channels * - Priority T1, Schedule P * - Cost for both tests: $1,045K including $630K capital facility, excluding WWM manufacture
2.16.D.1	* - Limited life cycle test to establish reliability * - Facility - as above * - Priority E2, Schedule F

GENERAL ATOMIC

CORE SERVICE TOOLS

RESERVE SHUTDOWN VACUUM TOOL (RSVT) TEST

DDN	DESCRIPTION
2.16.D.3	* - Confirm functional performance of RSVT and test preferred operation * - Full scale helium autoclave facility * - Priority T2, Schedule F * - Cost $100K

GENERAL ATOMIC

REACTOR SERVICE FACILITY TOOLS

DESIGN ADEQUACY TESTS - TOOLS IN FACILITY MOCK-UP

DDN	DESCRIPTION
2.16.D.4	* - Test the design adequacy of preliminary design reactor service facility tools * - Test Facility: Spatial mock-up with actual manipulators and shield windows * - Priority T2, Schedule P * - Cost $360K

GENERAL ATOMIC

CORE OUTLET T/C SERVICE TOOLS

DEVELOPMENT & FUNCTIONAL TESTS

DDN	DESCRIPTION
2.16.D.5	* - Development tests on cutter
	* - Engineering Lab Mock-up
	* - Priority T2, Schedule P
	* - Cost $60K

B40

GENERAL ATOMIC

REACTOR SERVICE EQUIPMENT
(SYSTEM 16)

COST SUMMARY:

	$ Millions
Design Plan Cost	6.54
Technology Plan Cost	1.57 (incl. 0.63 capital)
NSS Eqpt. Cost	6.54
TOTAL	$14.65

PART C

CONTROL & INSTRUMENTATION SYSTEMS

PRESENTERS: D. P. Giegler (GA)
H. A. Long (GA)
C. Rodriguez (GA)

PART C
CONTROL & INSTRUMENTATION SYSTEMS

The attendance and handouts for this presentation are attached at the end of these minutes for Part C of Session IIC.

I. CONTROLS & INSTRUMENTATION SYSTEMS OVERVIEW

Carmelo Rodreguez presented the controls and instrumentation systems overview. There are four control and instrumentaion systems, the overall plant control system which regulates the reactor conditions to maintain performance matching the demands of the steam system; the safety related system which takes protective action in case of abnormal conditions, the data acquisition system which provides the operator/plant interface, and the analytical instrumentation system which helps the operator monitor limiting conditions operations and the chemical impurities in the primary coolant.

II. OVERALL PLANT CONTROL SYSTEM

II.a Carmelo Rodriguez presented the portion of the handouts relating to the design description of the overall plant control system. The system includes the main and auxiliary control rooms. The latter is also known as the remote shutdown area where the operator can go to shutdown the reactor if the main control room becomes uninhabitable. The system maintains normal reactor power at 100%, main steam pressure at 2400 psia, and main steam temperature at 1000^{O}F. It also provides automatic load following capability for the plant. Additionally, it provides equipment protection which is distinguished from the safety protection; the purpose being to protect those items of equipment which are difficult to replace or repair - i.e., the circulators and steam generators. The high pressure turbine has a bypass on trip so that the process steam and low pressure turbine steam supplies will be maintained. Similarly, the low pressure turbine has a bypass to maintain the supply to the feed pump for the continued generation of process steam. The feed water rate is controlled to maintain the pressure in the process steam head 660 to 670 psia. Thus a reduction in process steam demand reduces the feedwater rate which, in turn, reduces the steam rate to the high pressure turbine.

The average steam outlet temperature is maintained at 1000^{o}F by control of the reactor power. The nuetron flux is also adjusted by a loop shutdown signal. This is the same system used at FSV. A reactor trip from the plant protection system (PPS) disables this control system and lets the reactor power and steam temperature decay.

The speed of each circulator is controlled by the loop feedwater rate in combination with the deviation of that loop's exit steam temperture from the average steam temperature at the exit of all the loops. This results in equalizing the power of the four loops. If only three loops are operating, the control system averages the exit steam temperature of these three loops.

The purpose of the loop trip sequences shown on viewgraph no. F-878 (6) are for the purpose of protecting plant equipment - not for safety.

The control room layout was developed from extensive work done on the Philadelphia Electric contract. All opertor action is taken at a horseshoe console arrangement. Monitoring data is provided on cabinets surrounding the console. An alarm is provided by a flashing red light on the CRT screen. The operator can select additional detail at his discretion including a display of the emergency procedures.

Mr. Rodriguez's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - If there is a decrease in the demand for process steam, there will also be a decrease in the total electrical power generation because of the decrease in total steam rate to the high pressure turbine.

2. R. Stearns - When the process steam demand is reduced, the high pressure turbine output is reduced and the low pressure turbine goes to the maximum power possible, but there is a net reduction in total electrical power generation.

3. F. Swart - A throttle on the low pressure turbine may be a possibility that is being analyzed to increase the electrical power generation with a decrease in demand for process steam. This would have the result of maintaining full flow through the high pressure turbine and letting the low pressure turbine take the swing.

4. L. Welshans - The plant is subject to the required balance between process steam and electrical power generation so that the needs of the process steam user are assured.

5. K. Van Howe - When the high pressure turbine trips, the steam is bypassed to the low pressure turbine inlet and the process steam header. The steam is throttled by one valve in the bypass to a pressure of 670 psia. The steam is desuperheated by the injection of feedwater at the bypass.

6. L. Welshans - Loss of one helium loop reduces reactor power by one fourth; first spiking below 75% power and then rebuilding to 75% power.

7. L. Welshans - Loss of one helium loop will result in a loss of electrical power generation but need not result in a reduction of process steam because the division of steam is 60% to process heat and 40% to the turbines.

8. C. Forkel - The controls to automatically maintain the process steam supply with the loss of one helium loop are not in the present system but they are being worked on.

9. K. Van Howe - The plant can continue to run indefinitely with one loop shutdown.

10. K. Van Howe - The reactivation of a shutdown loop requires a shutdown of the reactor to low enough power to get water in the steam generator of all the loops and then bringing the reactor back to full power.

11. C. Forkel - The time required to reactivate a shutdown loop is approximately one day.

12. V. Scotti - The problem of variable process heat load may be handled by the user being willing to base load the reactor and vary the natural gas generated steam. F. Swart also commented that a survey of process steam users indicated that there is usually a very diverse distribution to as many as 25 to 30 actual points of consumption among which only 2 or 3 may be shutdown at one time. Thus the total process steam demand may vary by only about 10%. Even so, Mr. Swart commented that a throttle valve seems to be needed on the low pressure turbine.

13. V. Scotti - Uniform heat generation in the reactor core is assumed, but the control system compensates for maldistribution in core by equalizing the loops to the average steam outlet temperature.

14. V. Scotti - The core orifice control system is manual at all times. This is the same system used at FSV. Automatic control is being looked at now.

15. K. Van Howe - A manual feedwater trim valve is provided in each of the loops.

16. K. Van Howe - The loop trips will be provided with set points and time delays such as to prevent spurious trips.

II.b. Carmelo Rodriquez presented the portion of the handouts relating to the design and technology plans for the overall plant control system. The control loops are configured and initially analyzed for stability and the control room allocations are made during conceptual design. During preliminary design the hardware is selected and the final stability analysis is performed. In the final design the actual wiring system is designed and the input to the test procedures and emergency procedures is generated. The control room will be simulated to verify compliance with new regulations that are being developed on emergency responsibilities, for use in operator training, and to verify compliance with plant availability and controlability requirements.

The design cost of $4M does not include the cost of BOP controls such as feedwater controls, nor DAS, nor safety controls.

Mr. Rodriguez's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. P. Kasten - The hybrid computer program is to do what used to be done by hand. It is for the purpose of trying various control strategies, tuning the control system, and control loop stability and sensitivity analysis. The final transient analysis will use the digital computer for documentation.

2. R. Stearns - The Midland experience will be considered. L. Welshans commented that Midland is a different problem in that there are two reactors; one on process steam and one on power. These are used alternately as required to meet process steam requirements.

3. L. Welshans - The schedule calls a new specification for the SC/C plant to be issued April 30, 1982.

4. P. Kasten- The cost of the technology program is $15M including operator training.

5. P. Kasten - the control simulator cost of $14M is due to the large computer that is required for the simulation which includes, in addition to the overall plant control system, all of the other control systems such as the one for the CACS, the primary cooling system, the nuclear flux control, and all of the others that are discussed separately in the presentations. The simulation, therefore, costs much more than the actual control system being tested.

III. SAFETY RELATED SYSTEMS

III.a. Donald P. Giegler presented the portion of the handouts related to the requirements and design description of the safety related systems. This is really a collection of three subordination systems - i.e., the plant protection system (PPS), the moisture monitoring system, and the special safety related control and instrumentation system. The reason for the three subordinate systems started in August 1977 when the NRC formed Task Action Committee A-34 and stepped up the emphasis on three regulatory guides - i.e., Regulatory Guide 1.22 for periodic testing of protection system activation functions. Regulatory Guide 1.47 on bypass and inoperable status indication for plant protection systems in nuclear power generating stations, and Regulatory Guide 1.97 on instrumentation for LWR's to assess plant conditions during and following accidents. IEEE 279 provides the overall criteria for the PPS. The interfacing systems all have constraints or requirements that they place on the safety related instrumentation system. GA adds the requirements for separation, segregation, channel response time, etc. for the consideration of the designers.

The reactor control rods are on non-Class-1E electrical power since the control rods go in the desired direction on power failure. The plant protection system, however, is on non-interuptable Class-1E power.

Viewgraph F-897 (4) is in error; the remote shutdown area is located in the reactor service area - not the control building.

The general overall requirement of the PPS is to assure that fission product barriers operate within the safety limits that are established in the plant specification for nuclear safety. Repeated, general, extended discussions developed over the properiety of including in the PPS a large part of the system which is actually directed toward protecting various items of equipment - not the public. The primary objection of the review team was that once the equipment protection features are included in the PPS, they become subject to regulation and can be changed only as the expense of long delays in traversing the regulatory procedure. This has been a problem at FSV. The GA representatives responded that the position of the review team had been argued with the NRC and lost on the Delmarva plants. The net result was a plea for GA to review the situation with the objective of keeping the bulk of the features in question, but transferring them from the PPS to a new system which might be titled "Equipment Protection System."

The PCRV relief valve closure interlock assures that there is a path to a relief valve at all times. It operates on sensing the redundant block valves position.

The action on the containment isolation system is to close the containment isolation valves, both in and out, and on high radiation to start the containment cleanup system.

The PPS structure is in five stages as shown in viewgraph F-867 (12). Each of three channels has its own transducer and feeds into two-out-of-three logic. Microprocessors handle the more complex PPS functions; the simpler functions are on a standard analog control board. The PPS users either transmission or hindrance logic. In transmission logic the system is normally deenergized and takes power to activate. In hindrance logic the system is normally energized and activation occurs on removal of power. The equipment is both environmentally and seismically qualified to IEEE 323 and IEEE 344, respectively. The basis for the limiting safety system settings, derived from the plant specification on nuclear safety, is 10 CFR 50, Paragraph 5036. The sensor checks are per IEEE 338 and Regulatory Guide 1.108. The single failure criteria that applies to the PPS structure is IEEE 379 and Regulatory Guide 1.53. The separation criteria for the PPS is IEEE 384 and Regulatory Guide 1.75. The availability is from the plant specification on availability. The reliability is from IEEE 352 which is a guide for the reliability analysis of PPS's.

The PPS employs two-out-of-three coincidence logic to initiate a protection system action. It has the capability to test the PPS logic, through optical isolators, to determine if a trip has occurred by the illimination of indicator lights.

The HTGR rod holding logic, viewgraph No. F-867 (14), is an example of hindrance logic. If any two of the three relay coils loose power, the power will be removed from the control rod holding motor.

The remote safe shutdown area entails portions of the PPS as illustrated in viewgraphs no. F-867 (10), F-867 (20), and F-867 (21).

In the PPS evolution from FSV, viewgraph F-867 (15), the first four items are technical improvements over FSV. The last four items re- lt from differences in structure between FSV and the SC/C plans.

At this point the presentation moved on the the moisture monitoring system. The accumulator tank in the compressor module is sized at 85 feet^3 and designed for 500°F. The filters in the filter module are redundant and are milipore, 10 micron filters which are impervious to water. The moisture detector head uses a chilled mirror and reflected light sensor. The temperature at which the mirror fogs indicates the moisture concentration. A moisture injection point is provided for testing. The filter removes solid particles from the sample stream to prevent reduction of the mirror's reflectance. The sample flow rate will be displayed and means will be provided for balancing flow. A compressor provides the driving force for the sample system; this is an improvement over FSV where this function was provided by the circulator differential pressure with resulting difficulties in controlling the flow rate because of varying differential pressure. The filter system is new from FSV and provision has also been made for cleaning the mirror.

At this point the presentation moved on to the safety related control and Instrumentation system. It consists of three subordinate systems that have been brought on by NRC Task Action Committee A-34; i.e., safety related display instrumentation (SRDI), post accident monitoring instrumentation (PAM), and core performance instrumentation (CPI). They perform functions that are related to safety but are not safety systems. The SRDI and PAM systems are safety grade class 1E but the CPI system is not.

The SRDI is active during normal plant operations, during an accident, and after an accident. It must be capable of checking each safety system imput sensor by peturbing the system variable it senses, or introducing a suitable substitute for that variable, or by cross check on a variable that has a known relationship to the variable being checked.

The PAM is a subnet of the SRDI. It concentrates on those variables most needed by the operator during and following an accident. The purpose is to determine the nature of the accident, verify that the correct protective action has been initiated, estimate the threat of the accident to the health and safety of the public, and allow the operator to determine if he should take additional manual action to mitigate the consequences of the accident.

The CPI monitors such variables as region flow, region power, region peaking factors, axial power profile, power-to-flow in a region, overall core power, and core inlet temperatures.

Mr. Giegler's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. L. Welshans - The moisture monitor is listed in connection with the interfacing systems because it is one of the three subordinate systems comprising the safety related systems. Parts of the moisture monitoring system have been specified and parts of it have not.

2. R. Stearns - The detection of radioactive material is part of the containment isolation system which is part of the PPS.

3. K. Van Howe - The interface between the safety system and the non-safety systems is at the isolation between the safety system and the system it's feeding. These interfaces are not all defined but the rules for finding them exist.

4. L. Welshans - Stopping the ingress of water to the primary coolant system protects the public because the water causes the primary coolant pressure to increase and this will open the PCRV safety valve.

5. R. Stearns - The primary coolant boundary is protected by protecting the tubes in the steam generator.

6. K. Van Howe - A slow rate of water ingress to the primary coolant system is damaging to the core because the reaction rate of the

graphite increases with the concentration of oxidants. The system trips at 500 ppm water. Redundancy on safety trips has been a historic characteristic. Cutting back on reactor power reduces the temperature and thus reduces the water's reaction rate with the graphite.

7. K. Van Howe - There are two steam dump valves per steam generator loop. The response time is 15 sec to open and 5 sec to close. Dumping stops when the pressure in the leaking loop reaches the primary coolant pressure.

8. F. Swart - The design pressure of PCRV is 1145 psia. Mr. Giegler did not know the set pressure of the relief pressure.

9. L. Welshans - GA is not advocating deletion of the containment building.

10. K. Van Howe - The trips for the CACS is at 10% rated feed water flow with two-out-of-three diverse logic.

11. L. Welshans - There is a five minute delay in the start of the CACS.

12. K. Van Howe - Combining the feedwater rate and high main circulator inlet temperature, with three channels each to start the CACS, may make the system so complicated that spurious trips may be increased. This problem should be left to the reliability specialists.

13. K. Van Howe - There is a manual bypass of the PCRV relief valve interlock with a key lock so that the block valves can be closed if a relief valve should stick open.

14. Unknown - if radioactivity is detected on the water side of a CAHE, it can be safely blocked in because there will remain two CAHE's in operation, which is adequate to cool the reactor under the worst condition. The SC/C plant has the same prohibits as FSV where, as last ditch, safe shutdown cooling is maintained.

15. Unknown - The radiation levels that activate the containment isolation system are yet to be determined to prevent the movementof a source through the area from causing a spurious trip of the system.

16. Unknown - The reason viewgraph F-867 (11) lists reactor service building radiation as initiating the containment isolation system is not understood. GA will review and answer later as whether this is a mistake.

17. K. Van Howe - Mr. Giegler did not know if the helium purification building is a containment building that shuts down on high radiation.

18. F. Swarts - Spurious trips of the plant during testing will be avoided by continuity checks to avoid a test being conducted in one channel in combination with a failed chip in another channel. Mr. Swart remained unconvinced, because of the high incidence of spurious trips at FSV, and continued to favor an actual disconnect from the plant during testing.

19. L. Welshans - The safe shutdown room control boards inform the operator of the plant condition and provide him with the ability to act with respect to the neutron region flow control system and the CACS.

20. L. Welshans - The moisture monitor system does differentiate between loops. There is a moisture detector on each loop. When tripped, only the leaking steam generator is dumped and the reactor is shutdown.

21. P. Kasten - If the circulator seal is leaking water, there will be a loop shutdown and the shutdown seals will be closed when the circulator has stopped. The reactor will not be shutdown.

22. P. Kasten - A circulator seal leak can be distinguished from a steam generator leak by sensors in the scavenging chamber for the level of

the water and radiation sensors in the surge tank to determine the condition of the seal in the circulator.

23. P. Kasten - The moisture monitor sample point is located at the circulator diffuser outlet.

24. Unknown - Locating the moisture monitor sample point at the steam generator outlet instead of the curculator outlet will make it much less accessible.

25. L. Welshans - The moisture monitor will trip at 100 ppm on a two-out-of-three basis without a circulator seal malfunction or a 500 ppm reactor trip absolute.

26. P. Kasten - The moisture monitor sample line is temperature controlled to be sure that condensation doesn't occur. Condensation has been a problem before.

27. Unknown - The monitor detector is to be a commercially available unit such as made by EG&G.

28. R. Evans - The heat trace temperature of the moisture monitor sample line has not been determined yet.

29. K. Van Howe - The mirror cooling media has not been selected. Liquid nitrogen has been considered.

30. F. Swart - The response time of the moisture monitoring system is 20 sec.

31. F. Swart - The SRDI reflects the lessons learned from TMI.

32. K. Van Howe - The PAM performs functions that were taken from the data acquisition and processing system (DAP) by regulatory fiat.

33. K. Van Howe - The PAM includes a radiation monitoring capability.

III.b. Donald P. Giegler presented the portion of the handouts related to the design and technology plans for the safety related systems. The model of the plant will be used to determine what the accident and transient response of the plant is in order to provide the safety system settings and functions in a more detailed manner. A failure mode and effects analysis will also be performed for the safety related instrumentation system. This will check such things as single failure criteria - a failure is assumed in one of the channels of the PPS and the other two channels should carry out the intended function. The environmental and seismic specifications will be developed for equipment in the safety system. Concurrently, there will be some testing performed as required by the design data needs such as the design verification of the moisture monitor. There are a number of questions to be answered with respect to measuring the mass flow rate of the helium.

The costs are plotted separately for the PPS, the moisture monitoring system, and the special safety related system. The late peak on the cost of the moisture monitoring system is for design verification - the testing of the actual, installed article (see the response to question 9). The SRDI prices are not included in viewgraph F-897(5); this is estimated to be $3M based on the experience of GA's electronic system division with similar systems for light water reactors.

Mr. Giegler's response to specific questions raised during the course of his presentation are listed below by the name of the inquirer.

1. P. Kasten - The design verification of the moisture monitor is spread out over three years at a low level in order that the delay will permit compliance with the latest possible regulations.

2. K. Van Howe - Testing of the helium mass flow rate measurement system will be performed in conjunction with the circulator test.

3. Unknown - The circulator inlet shroud will be replicated for the test of the helium mass flow rate measurement system.

4. F. Swart - It will be verified that the thermocouples can be installed in their thermowells; however, the response time is the main point at issue.

5. Unknown - GA is not developing any new instrumentation.

6. P. Kasten - The difference between qualification and verification is: in qualification, the equipment is exposed to the seismic and environmental conditions in which it would be expected to operate, whereas in verification, the entire system would be assembled and tested to show that it will perform as intended.

7. Unknown - Qualification of equipment for radiation is included under IEEE 323, but normally all solid state equipment is kept away from a radiation environment.

8. K. VanHowe - It appears that the late peak cost on the moisture monitor for design verification testing of the actual installed article is incorrectly included with technology development. GA will review this and adjust as necessary (see Part D, Question 6).

9. P. Kasten - There are three hygrometer modules on each steam generator loop for a reactor total of twelve.

IV. DATA ACQUISITION AND PROCESSING SYSTEM (DAP)

IV.a. Henry A. Long presented the portion of the handouts related to the requirements and design description of the DAP. The DAP is the primary plant-to-operator information interface. The provided information includes fuels burnup information for off-site fuels management and operational information for historical records. The sequence of events monitoring of digital contacts has a very fine time resolution of 2 msec - this is used primarily for future diagnosis of a trip to determine what caused it. The cathode ray tubes (CRTs) are color which provides another degree of freedom in the display. The post trip review will record approximately 500 parameters for a one-hour period after which they will be overwritten if there is no event or other reason to examine the data. If a trip or plant excursion occurs, the last hour's performance will be available to study the sequence of events leading up to the occurrence and how the plant recovered. The operator guides are provided by the color CRTs to guide the operator through various procedures such as startup, shutdown, and load changes. This saves the operator the need to refer to a manual for written procedures. The emergency operations facility support is in response to Nureg 696 and the post-TMI requirements for information displays. The intent with this system is to use the basic plant computers of the DAP to generate the data that will go to the technical support center, the emergency operations facility, and the nuclear data link. The fourth function described in Nureg 969 is the safety parameter display system (SPDS). The intent is to also generate the safety parameter display on a color CRT. The DAP is not intended to be seismically hardened, but the SPDS will be hard wired as mandated by Nureg 696.

The continued function of the DAP is not essential to protect the public; but, the diagnostic capabilities and the operator information for continued operation of the plant are so important that an availability of 99.99% is being sought. This is equivalent to a mean time to repair of four hours out of two years. This is accomplished by the use of two completely redundant computers. One can monitor while the other is accruing data that is not being used. Program development or diagnostics can be performed on one while the other is being used, but on failure of the monitoring computer it switches to the other computer.

The CRT displays are driven by independent display generators in such a fashion that no single failure can take out all of the CRTs.

The sequence of events monitor takes the calculational load off of the main DAP computer. It separates out the contact closures or other binary events of the 2 msec time resolution and provides the order with which any contacts changed state to the DAP system computer.

The control room simulator will tie into the DAP. It will be provided with similar CRTs.

The DAP receives inputs from the various safety systems. These are isolated in such a way that no type of failure in the DAP can degrade the safety systems. The safety parameter display will be driven from the DAP system but will be backed up by a separate seismically hardened SPDS provided under the safety related instrumentation system.

The use of remote multiplexing provides a very large potential to save on plant wiring costs and to improve the quality of the instrument signals flowing into the computer of the DAP.

Human factors will receive a major emphasis. This is consistent with the policies GA has used on the advanced HTGR work in the past and is more emphasized with the post-TMI 2 documents coming out of NRC.

A prototype of the system is now being operated. The actual system for Summit Plant was completed after the plant was canceled and is being used with some new experimental hardware testing.

Actual photographs of the CRT displays are included in the handout. An alarm is indicated by a field of red. Such an alarm is indicated by the photograph for the steam generator status for the reheat steam outlet temperature of 1017°F on Loop B. The control rod position display shows whether a rod is in or out, and if it is in an intermediate position, the number of inches withdrawn. It also provides a flat cable indicator so that the operator may distrust the indicated rod position.

There were no questions raised during the course of Mr. Long's presentation.

IV.b. Henry A. Long presented the portion of the handouts related to the design and technology plans for the DAP.

The scheduled performance of the failure mode and effects analysis has been slipped to allow the input of the maximum possible information of the actual, deliverable DOP computer hardware. The greatest evolutions occur in central processing units (CPU's) and some of the memory components. It may be practical to upgrade this system both before and after commercial operation to take advantage of the latest equipment that is smaller and lower cost.

The peak in the expenditure chart represents the period during which the bulk of the work on the application programs development will occur. The late peak is to allow the incorporation of a maximum amount of other plant design data needs into the application programs before they are written.

There were no questions raised during the course of Mr. Long's presentation.

V. ANALYTICAL INSTRUMENTATION SYSTEM

The presentation of the analytical instrumentation system was cancelled but the handouts for it are included at the end of these minutes for Part C.

VI. CONTROL AND INSTRUMENTATION SYSTEMS SUMMARY

This part of the agenda was included with the Working Session, Part D.

Attendance
Scession II C
12/10/81

Name	Organization
Fred Swart	GCRA
CURT FORKEL	EG&G
JAMES ZGLICZYNSKI	GA
Hank Fong	GA
W.H. ROACH	EG&G
L.M. WELSHANS	DOE
K.R. VAN HOWE	SMSC
Robert F. Stearns	Bechtel
John M. Gurley	Gen. Elec. ARSD
C.R. BOLAND	GA.
PAUL KASTEN	ORNL
CLIVE DUPEN	C-E
Vincent G. SCOTTI	CE
R.A. Evans	GCRA

C20

PLANT CONTROL SYSTEM

GENERAL ATOMIC COMPANY

GENERAL ATOMIC

OVERALL PLANT CONTROL SYSTEM SCOPE/OBJECTIVES

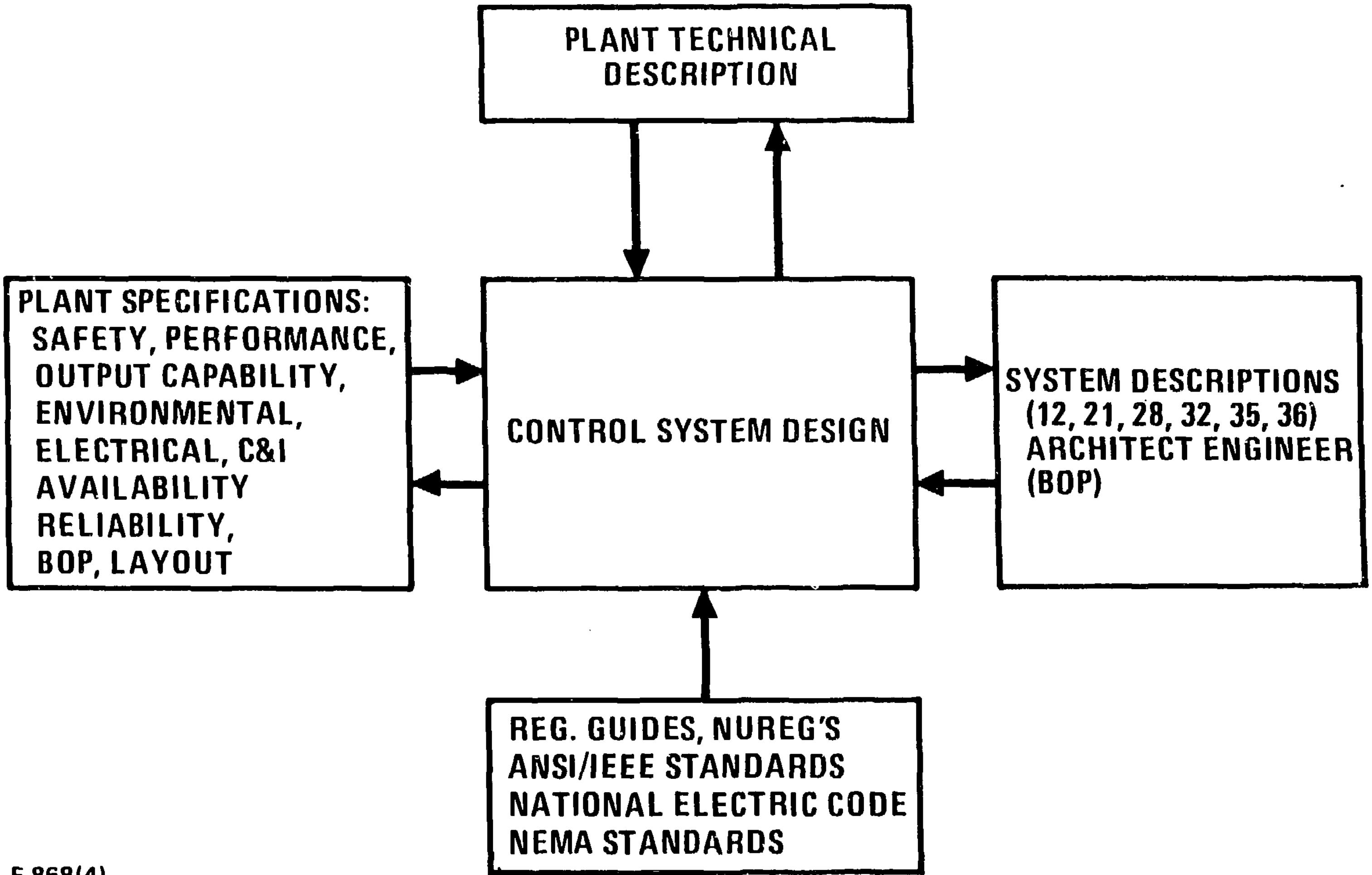
HUMAN ENGINEERED FOR SAFE REACTOR OPERATION AND HIGH PLANT AVAILABILITY
- MAIN AND AUXILIARY CONTROL ROOMS

REGULATE REACTOR CONDITIONS
- MAINTAIN NOMINAL PERFORMANCE
- PROVIDE AUTOMATIC LOAD FOLLOWING CAPABILITIES
- ACCOMMODATE NSS AND BOP PERTURBATIONS

EQUIPMENT PROTECTION AGAINST PROLONGED PLANT UNAVAILABILITY

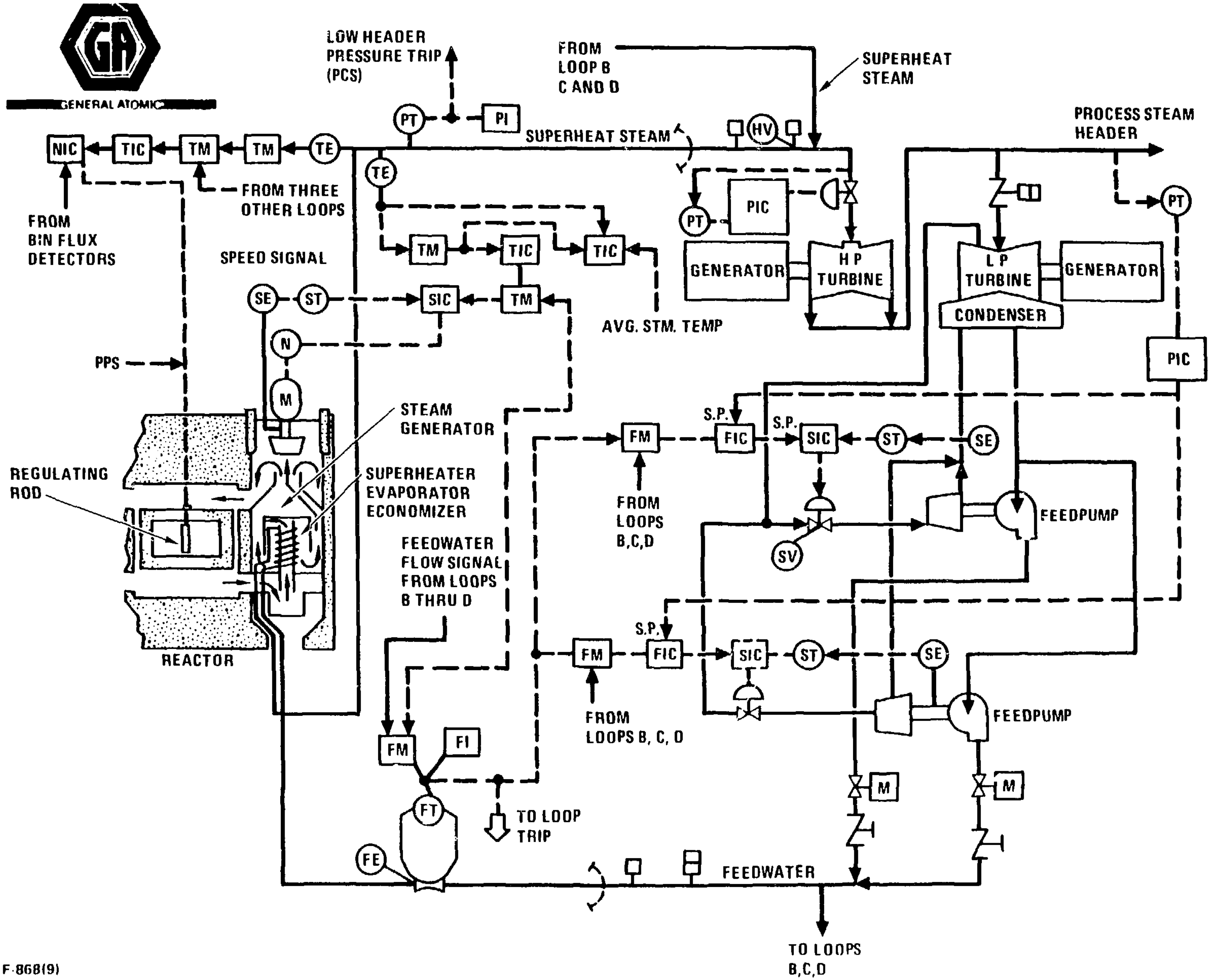
GENERAL ATOMIC

OVERALL PLANT CONTROL SYSTEM DESIGN REQUIREMENTS



C22

F-868(4)

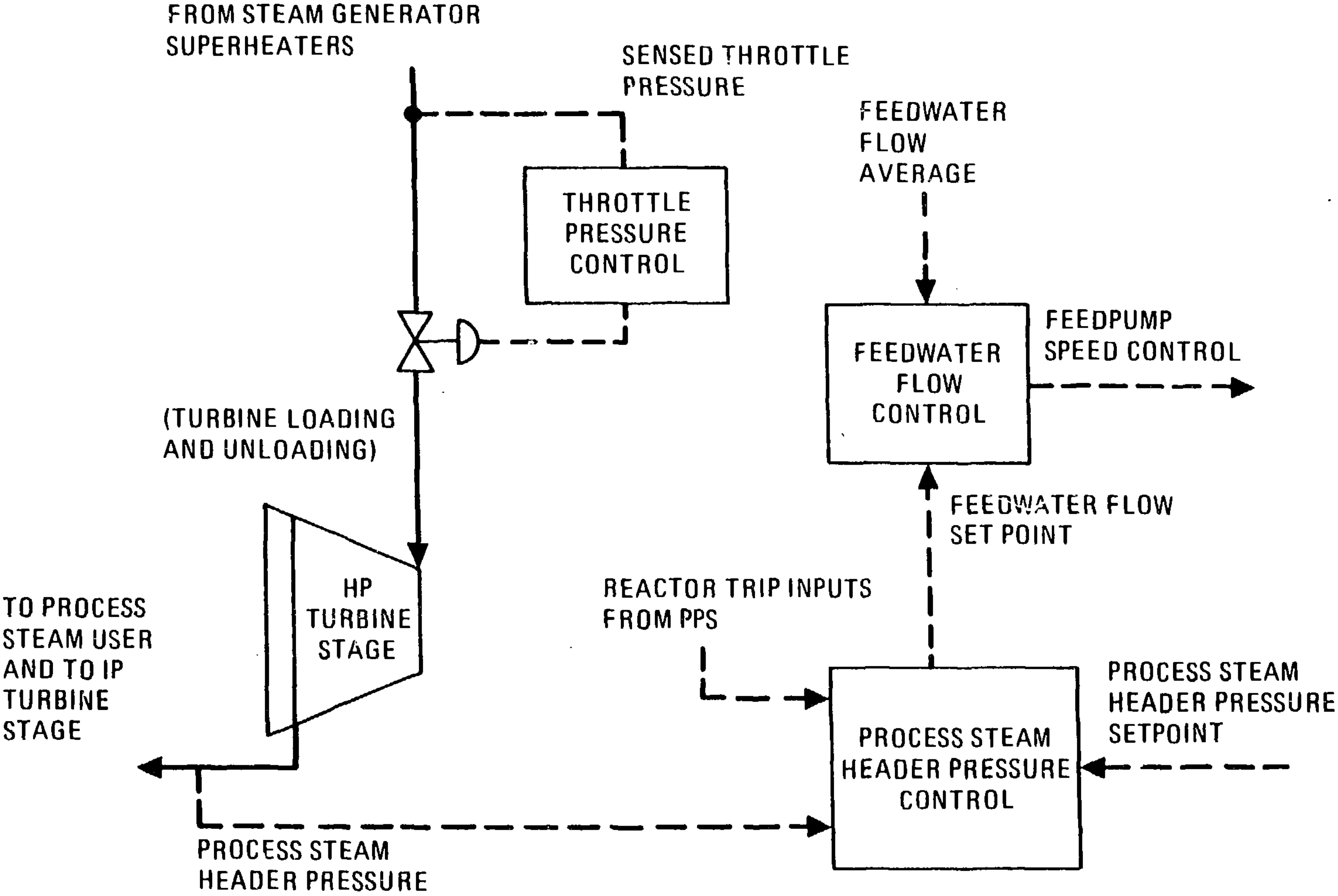


GENERAL ATOMIC
LOW HEADER PRESSURE TRIP (PCS)
FROM LOOP B C AND D
SUPERHEAT STEAM
PROCESS STEAM HEADER
PT
PI
NIC
TIC
TM
TM
TE
SUPERHEAT STEAM
HV
FROM THREE OTHER LOOPS
FROM BIN FLUX DETECTORS
TE
PIC
PT
TM
TIC
TIC
SPEED SIGNAL
GENERATOR
H P TURBINE
L P TURBINE
GENERATOR
CONDENSER
SE
ST
SIC
TM
AVG. STM. TEMP
N
PPS
M
PIC
STEAM GENERATOR
S.P.
FM
FIC
S.P.
SIC
ST
SE
REGULATING ROD
SUPERHEATER EVAPORATOR ECONOMIZER
FEEDPUMP
FROM LOOPS B,C,D
SV
FEEDWATER FLOW SIGNAL FROM LOOPS B THRU D
REACTOR
S.P.
FM
FIC
SIC
ST
SE
FROM LOOPS B, C, D
FEEDPUMP
FM
FI
FT
M
M
TO LOOP TRIP
FE
FEEDWATER
TO LOOPS B,C,D

F-868(9)

GENERAL ATOMIC

MAIN STEAM PRESSURE CONTROL (NORMAL PLANT OPERATION)



F-878(5)

C24

MOISTURE MONITOR SYSTEM OBJECTIVE

- DETECT PRIMARY COOLANT MOISTURE

TO:

- MINIMIZE GRAPHITE/H_2O REACTION
- PREVENT PRIMARY COOLANT PRESSURE FROM RISING TO PCRV RELIEF VALVE SETTING

764

F-867(23)

GENERAL ATOMIC

PPS EVOLUTION FROM FSV

- TEST BYPASSES
- PRETEST CONTINUITY CHECKS
- PROGRAMMABLE TEST LOGIC
- OPTO-ISOLATORS
- CACS INITIATION & CAHE ISOLATION IN HTGR SC/C DESIGN/ PELTON WHEEL START IN FSV DESIGN
- HIGH STEAM GENERATOR INLET GAS TEMPERATURE REACTOR TRIP IN HTGR SC/C DESIGN/HIGH REHEAT STEAM TEMPERATURE SCRAM IN FSV DESIGN
- MAIN CIRCULATOR PROTECTIVE FUNCTIONS MOVED TO PCS
- CIS IN HTGR SC/C DESIGN

C63

SAFE SHUTDOWN ROOM CONTROL BOARDS

GENERAL ATOMIC

BOARD DESIGNATION	BOARD TITLE	INSTRUMENTATION	QTY PER LOOP
—		AUX CIRCULATOR MOTOR COOLING WATER PUMP CONTROL	2
	PPS CONTROL ROD POWER DISTRIBUTION CENTERS	REACTOR TRIP CIRCUIT BREAKER	—
	MAIN LOOP SHUTDOWN CONTROL BOARD	BOILER FEEDWATER TRIM VALVES	1
		BOILER FEEDWATER BLOCK VALVES	1
		MAIN CIRCULATOR HELIUM ISOLATION VALVES	1
		MAIN CIRCULATOR MOTOR BREAKER	1

C62

F-867(21)

SAFE SHUTDOWN ROOM CONTROL BOARDS

BOARD DESIGNATION	BOARD TITLE	INSTRUMENTATION	QTY PER LOOP
—	CACS LOOP CONTROL BOARDS (DUPLICATION OF 12803/A/B/C)	AUX CIRC MOTOR TEMPERATURE	1
		AUX CIRC MAIN CIRCUIT BKR	1
		AUX CIRC START SWITCH	1
		AUX CIRC PHASE VOLTAGE	1
		AUX CIRC PHASE CURRENT	1
		AUX CIRC FREQUENCY	1
		AUX CIRC SPEED	1
		AUX LOOP CUTOFF VALVE	1
		AUX HEAT EXCHANGER TEMP	1
		AUX COOLING WATER INLET VALVE	1
		AUX COOLING WATER OUTLET VALVE INDICATOR	1
		AUX COOLING WATER PUMP CONTROL	1
		BUFFER HELIUM COMPRESSOR CONTROL	—

SAFE SHUTDOWN ROOM CONTROL BOARDS

GENERAL ATOMIC

C60

BOARD DESIGNATION	BOARD TITLE	INSTRUMENTATION	QTY PER LOOP
I3273A/B	RSS ACTUATION LOCAL CONTROL BOARDS	MASTER RSS ACTUATION SWITCHES	–
		RSS POWER	–
I12XX	CONTROL ROD INDICATION BOARD	CONTROL RODS INSERTED LIGHTS	–
		WIDE RANGE POWER LEVEL METERS	–
I21XX	PRIMARY COOLANT MONITOR BOARD	AUXILIARY LOOP HELIUM OUTLET TEMP	3
		REACTOR INLET PRESSURE	–

F-867(19)

General Atomic
Incorporated
2 RELEASED 1-27-78

EXAMPLE PCS INSTR. DATA SHEET
ELECTRONIC CONVERTER DATA SHEET

SPECIFICATION FOR PROCESS INSTRUMENT PACKAGE

PROJ. NO. 90	SPEC. NO. 93-I-2	ISSUE	DATE	PAGE OF

GENERAL	INSTRUMENT NO. (MARK NO.)	TM-2255-1	TM-2256-1	TM-2255-2	TM-2256-2
	SERVICE	LOOP 1 MODULE	LOOP 2 MODULE	LOOP 1 MODULE	LOOP 2 MODULE
		REHEAT STEAM	REHEAT STEAM	REHEAT STEAM	REHEAT STEAM
		TEMP.	TEMP.	TEMP.	TEMP.
	LOCATION	I-37	I-38	I-37	I-38
	INSTRUMENT TYPE	SUMMING AMPLIF	→	→	→
	USE FOR	FLUX CONTROL &	→	→	→
		TEMP DEV. ALARM	→	→	→
INPUT	INPUT FROM (INSTR.NO.)	TT-2255-4,5,6	TT-2256-4,5,6,	TT-2255-1,2,3 & TM-2255-1	TT-2256-1,2,3 & TM-2256-1
	INPUT SIGNAL	10-50 MA	→	→	→
	RANGE/CALIBRATION	700-1100/°F	→	→	→
				TDM-2255-1 TDM-2255-2	TDM-2256-1 TDM-2256-2
OUTPUT	OUTPUT TO (INST. NO.)	TM-2256-2	TM-2256-2	TM-2253-3	TM-2256-3
	OUTPUT RANGE	700-1100°F	→	→	→
	OUTPUT SIGNAL	10-50 MA	→	→	→
	LOAD IMP. RANGE	0-660Ω	→	→	→
	COMPUTATION, OUTPUT = f(A,B,C,D)	(A+B+C) · 1/3	→	(A+B+C+3D) 1/6	→
	ACCURACY	±0.5% OF SPAN	→	→	→
	ZERO ADJUSTMENT	–25 TO +100% SPAN	→	→	→
	SPAN ADJUSTMENT	±2% OF SPAN	→	→	→
CASE	CASE, SIZE & TYPE	–	–	–	–
	CONSTRUCTION	–	–	–	–
	MATERIAL/COLOR	–	–	–	–
	MOUNTING	RACK	→	→	→
MISC.	LOCAL INDICATOR	NO	→	→	→
	BURNOUT PROTECTION	–	–	–	–
	REF DWG	CG-66504	→	→	→
	POWER SUPPLY	BUS I	BUS II	BUS I	BUS II
	POWER CONSUMPTION	10 WATTS			
	MANUFACTURER	FOXBORO	→	→	→
	MODEL NO.	M/66 CC-OH30	→	M/66 CC-OH40	→
	PI OR CI REF. DWG.	PI-22-4	PI-22-9	PI-22-4	PI-22-9
	NOTES: FOXBORO BLOCK DIAGRAM	BD-22 SH. 7	→	→	→

DATA SHEET NO. CR-133

REV.	DESCRIPTION	ENG.	CHK.	APPROVALS	DATE
2	REVISED PER FCN-4127:	NO			1-27-78
1	ISSUE FOR FABRICATION	HL		T.G.D.	8-6-69
0	FOR SELLER INFORMATION & COMPLETION	HL		T.G.D.	12-10-68

GGA FORM 387 11-67 MISC. INSTR. DATA SHEET

F-867(18)

General Atomic Incorporated

2 RELEASED 1-20-78

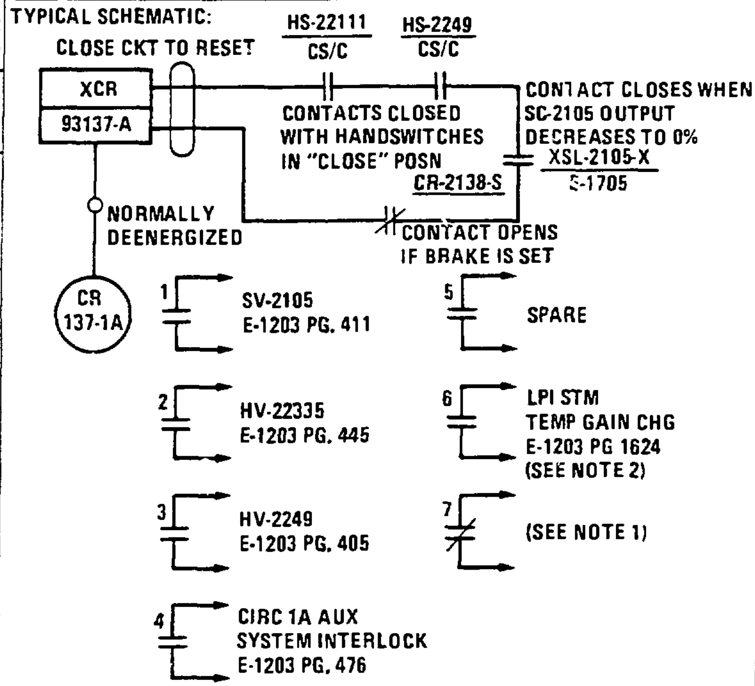
EXAMPLE PPS INSTR. DATA SHEET

SPECIFICATION FOR PROCESS INSTRUMENT PACKAGE				XR-102
PROJ. NO. 90	SPEC. NO. 93-I-1	ISSUE	DATE	PAGE 1 OF

SERVICE: PPS OUTPUT TO CLOSE CIRCULATOR STEAM TURBINE CONTROL VALVE AND CIRCULATOR TRIP VALVE.

RELAY(S) PER DRIVER: 1 CONTROL RELAY (SoD 0.8501-GC-60)

TYPICAL SCHEMATIC:



INSTRUMENT NUMBER	OUTPUT	RESET BY:		E-1203 REFERENCE OUTPUT	E-1203 REFERENCE RESET	ELJ 169-	I-10 LOCATION	INST BUS
XCR-93137-A	SV-2105, HV-22335, HV-2249	HS-22111,-2249	CR215 1A	411, 445, 405, 476, 1624	405	3100	1201/P11	I
XCR-93137-B	" " "	XSL-2105-X	1B	" " " " (NOTE 2)	"	3101	1001/P11	II
XCR-93138-A	SV-2106, HV-22336, HV-2250	HS-22112,-2250	CR2152 1A	412, 446, 406, 489, (NOTE 2)	406	3102	601/P11	I
XCR-93138-B	" " "	XSL-2106-X	1B	" " " " ,1624	"	3103	401/P11	II
XCR-93149-A	SV-2111, HV-22337, HV-2251	HS-22113,-2251	CR2155 1A	413, 447, 407, 482, 1624	407	3100	1201/P9	I
XCR-93149-B	" " "	XSL-2111-X	1B	" " " " (NOTE 2)	"	3101	1001/P9	II
XCR-93150-A	SV-2112, HV-22338, HV-2252	HS-22114,-2252	CR2159 -1A	414, 448, 408, 494 (NOTE 2)	408	3102	601/P9	I
XCR-93150-B	" " "	XSL-2112-X	1B	" " " " ,1624	"	3103	401/P9	II

MFG/MODEL: GA/ESD/XCR-1

REF. DWGS: IB-93-8, ELD-154-0000-1

NOTES: (1) RESETTING XCR-93137-A & XCR-93145A RESETS XCR-93163A

DATA SHEET NO. XR-102

REV.	DESCRIPTION	ENG.	CHK.	APPROVALS	DATE
2	PER FCN 4214 – REFLECT AS-BUILT CONFIGURATION	JV			1-9-78
1	ADDED OUTPUTS TO CIRCULATOR TRIP VALVE & AUX. SYSTEM INTERLOCK	HL			8-7-68
0	FOR USE WITH SPEC 93-I-1	HL			1-31-68

F-867(16)

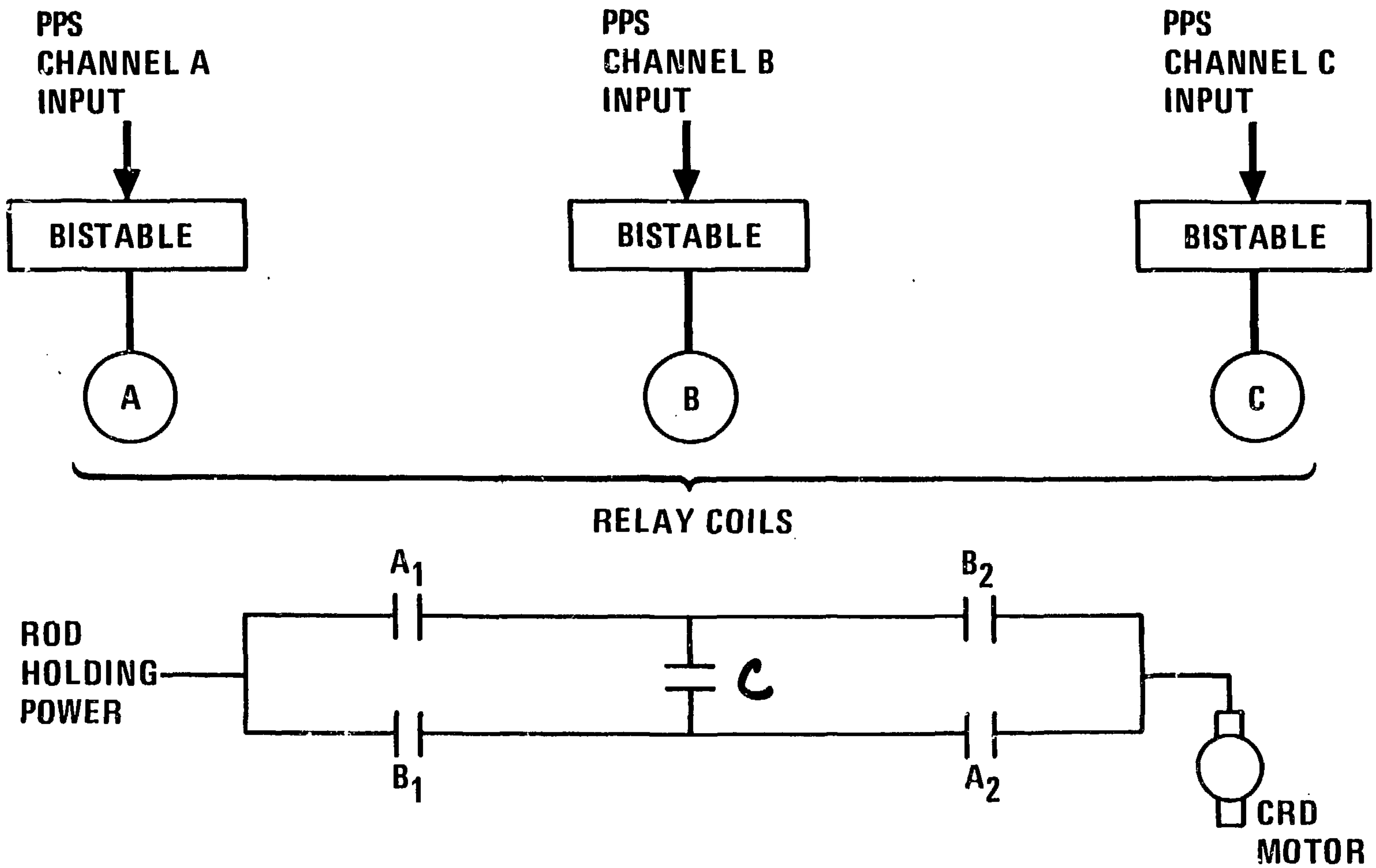
GENERAL ATOMIC

EXAMPLE CABLE TAB

```
FT ST VRAIN GENERATING STATION CABLE TAB GADWG 90-1-9301-700, ISSUE F                  DATE 080580       PAGE 1002
  CABLE   CLSS  ...............................FROM.........................  END         PB  ..........FUNCTION...................  GPND   ..B/M..         LAST CHNG
  .SER.   .SD.  ...............................TO...........................  ENO         NO. CON   SIZE   .INSULATION.          COV          SHEET
**************************************************************************************************************************************************************
C13035          MCB I-09 (N6) 12BPY-1                                                      NO 2 BUS PT SEC                                                  FCN-3301
     C          SWYD RELAY PNL 3S                                                    4/C          10     600V PE-PVC       PVC       1303

          TRAY  ZT   R11   B5   K25   MH1B   K13
  ROUTING OSGN       11C        11C   11C    11C
           LOC        AX        UD     MH    UD

A13036          MCB I-09 (N6) 1BP-1                                                        NO 1 BUS PT SEC
     C          MCB I-09 (N5)                                                        7/C          10     600V PE-PVC       PVC       1303

          TRAY INT
  ROUTING DSGN
           LOC
A13037          MCB I-09 (N6) 2 BP-1                                                       NO 2 BUS PT SEC
     C          MCB I-09 (N5)                                                        7/C          10     600V PE-PVC       PVC       1303

          TRAY INT
  ROUTING DSGN
           LOC
A13038          MCB I-09 (N5) 1BP-1A                                                       NO 1 BUS PT SEC
     C          MCB I-09 (N4)                                                        7/C          10     600V PE-PCV       PVC       1303

          TRAY INT
  ROUTING DSGN
           LDC
A13039          MCB I-09 (N4) 1BP-1B                                                       NO 1 BUS PT SEC
     C          MCB I-09 (N3)                                                        7/C          10     600V PE-PVC       PVC       1303

          TRAY INT
  ROUTING DSGN
           LOC
A13040          MCB I-09 (N3) C5317                                                        5317 PCB CONTROL CN-759                                          FCN-4597
     C          SWYD RELAY PNL 2S                                                    12/C         10     600V PE-PVC       PVC       1304

          TRAY  27T2  40T2  41T2  R12  B6   K48  MH1D  MH1C **** K12
  ROUTING DSGN  12C   12C   12C   12P       12P  12C   12P       11P
           LOC   AX    AX    AX    AX        UD   MH    MH        UD
D13041          MCB I-09 (N4) M5307                                                        CT SEC METERS CN320                                              FCN-4289
     C          SWYD RELAY PNL 2N                                                    4/C          10     600V PE-PVC       PVC       1304
```

C57

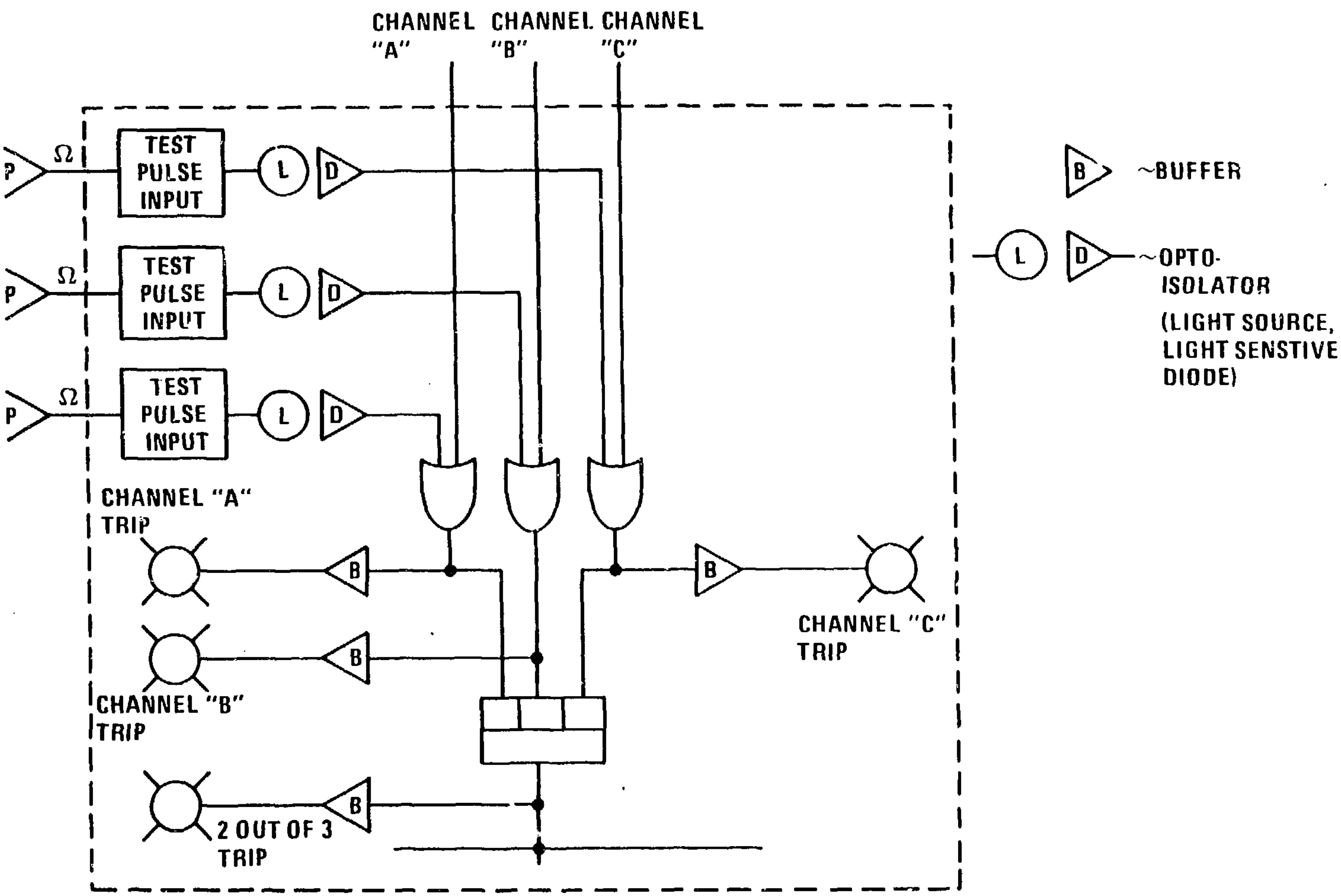
HTGR ROD HOLDING LOGIC



C56

F-867(14)

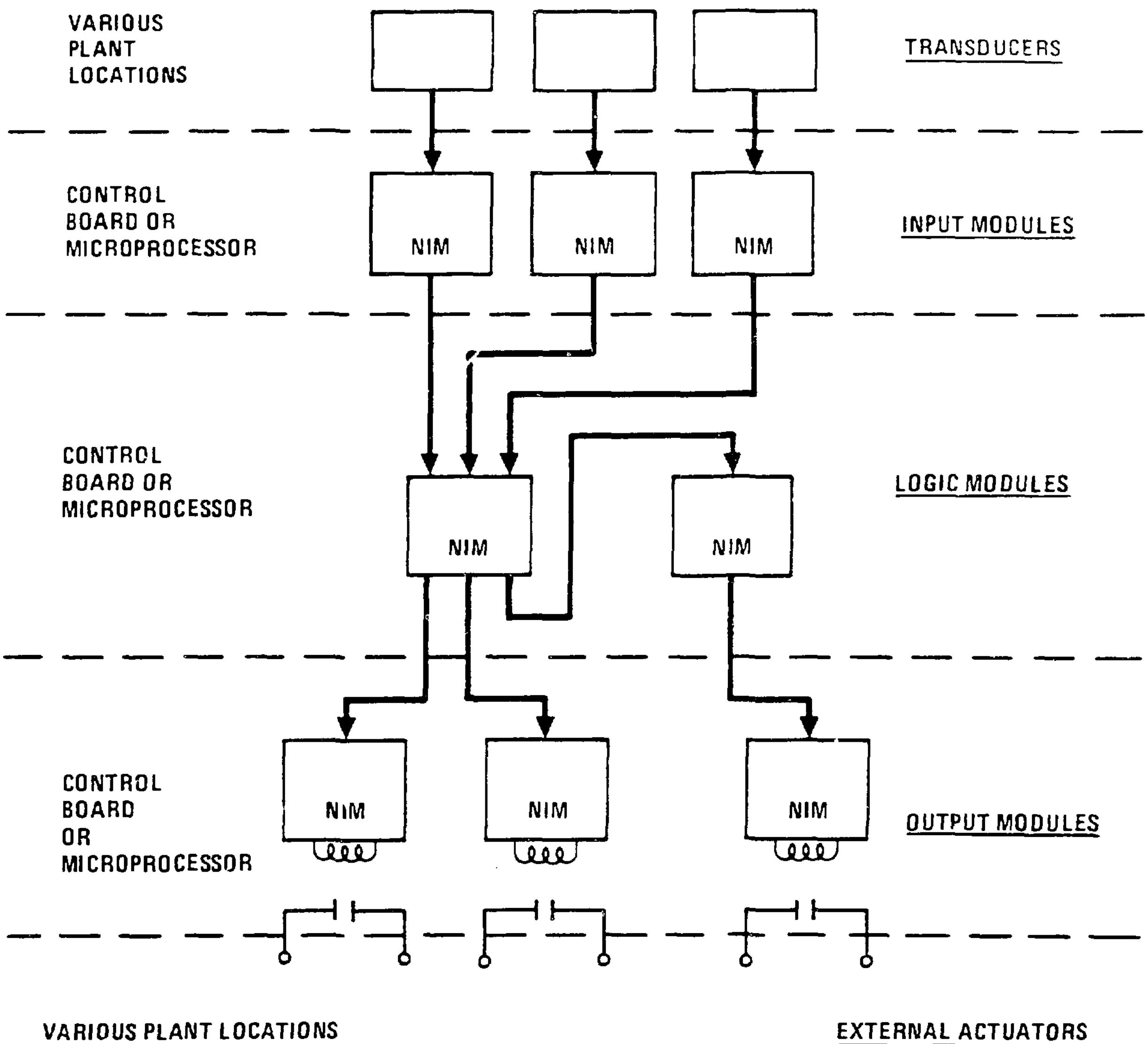
HTGR PPS 2/3 LOGIC



C55

F-867(13)

PPS STRUCTURE



F-867(12)

GENERAL ATOMIC

CONTAINMENT ISOLATION SYSTEM

C53

HIGH CONTAINMENT PRESSURE

HIGH CONTAINMENT RADIATION

REACTOR SERVICE BUILDING
RADIATION

F-867(11)

GENERAL ATOMIC

CAHE ISOLATION SYSTEM

C52

- HIGH CORE AUXILIARY COOLING WATER RADIOACTIVITY
- LOW-CORE AUXILIARY COOLING PRESSURIZER LEVEL AND PRIMARY COOLANT MOISTURE CONCENTRATION

PCRV PRESSURE RELIEF VALVE CLOSURE INTERLOCK

GENERAL ATOMIC

C51

- REDUNDANT BLOCK VALVE NOT FULLY OPEN

F-867(9)

CACS INITIATION SYSTEM

LOW PLANT FEEDWATER FLOW RATE

LOW PLANT HELIUM FLOW RATE

HIGH CONTAINMENT PRESSURE

F-867(8)

GENERAL ATOMIC

MAIN LOOP SHUTDOWN SYSTEM

HIGH CIRCULATOR OUTLET HELIUM TEMPERATURE

HIGH SUPERHEAT STEAM TEMPERATURE

C49

F-867(7)

STEAM GENERATOR HEADER ISOLATION AND DUMP SYSTEM

GENERAL ATOMIC

C48

HIGH PRIMARY COOLANT MOISTURE CONCENTRATION (ANY HEADER)

LOW SUPERHEAT STEAM PRESSURE (DUMP TERMINATED)

GENERAL ATOMIC

REACTOR TRIP SYSTEM

C47

- HIGH PRIMARY COOLANT PRESSURE
- LOW PRIMARY COOLANT PRESSURE
- HIGH PRIMARY COOLANT MOISTURE CONCENTRATION (ANY HEADER)
- HIGH STEAM GENERATOR INLET HELIUM TEMPERATURE
- HIGH REACTOR POWER LEVEL
- HIGH REACTOR POWER-TO-HELIUM MASS FLOW RATIO
- HIGH CONTAINMENT PRESSURE

GENERAL ATOMIC

PLANT PROTECTION SYSTEM (PPS)
SYSTEM 32–1

- REACTOR TRIP
- STEAM HEADER ISOLATION AND DUMP
- MAIN LOOP SHUTDOWN
- CORE AUXILIARY COOLING SYSTEM INITIATION
- PCRV PRESSURE RELIEF BLOCK VALVE CLOSURE INTERLOCK
- ROD BANK WITHDRAWAL INTERLOCK
- CORE AUXILIARY HEAT EXCHANGER ISOLATION
- CONTAINMENT ISOLATION

PLANT PROTECTION SYSTEM (PPS)
SYSTEM 32–1 OBJECTIVE

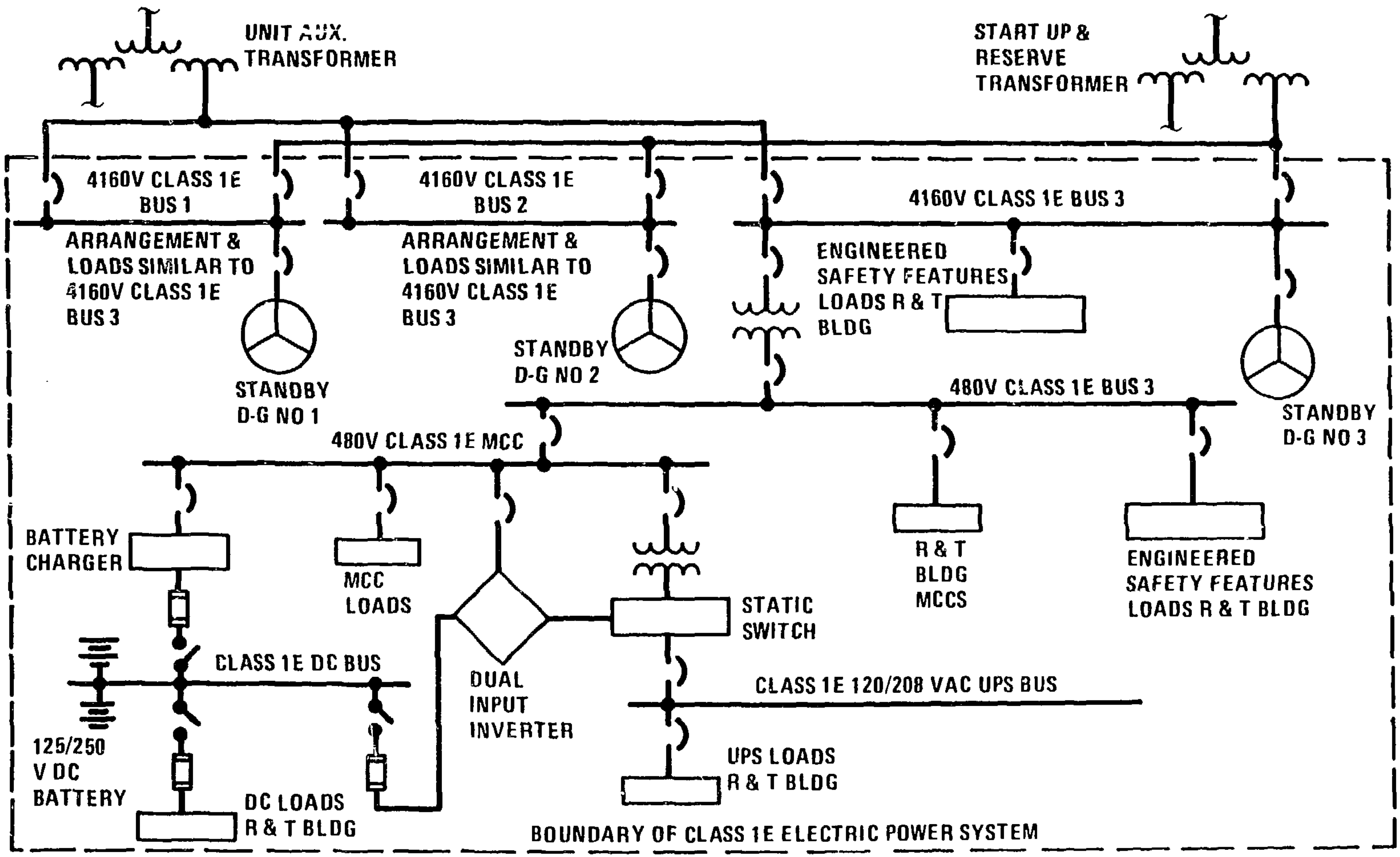
- PREVENT RADIOACTIVE RELEASES HAZARDOUS TO HEALTH AND SAFETY OF PUBLIC

BY:

- INITIATING ACTION TO PROTECT FISSION PRODUCT BARRIERS
- LIMITING RADIOACTIVE RELEASES IF FAILURES OCCUR IN THE BARRIERS

C45

HTGR CLASS 1E ELECTRIC POWER SYSTEM



C44

F-867(31)

GENERAL ATOMIC

SAFETY RELATED SYSTEMS
SYSTEM 32
NSS/BOP INTERFACES

SYSTEM IDENTITY	INTERFACE DESCRIPTION
ELECTRIC POWER (92)	PROVIDES MOISTURE MONITOR CLASS IE 480 V AC POWER. PROVIDES MOISTURE MONITOR CLASS IE UPS POWER.
PLANT CONTROL BUILDING (77)	HOUSES MOISTURE MONITOR INDICATORS AND EQUIPMENT IN THE MAIN CONTROL BOARD.
REACTOR CONTAINMENT BUILDING (72.1)	HOUSES MOISTURE MONITOR HYDROMETER AND COMPRESSOR MODULES AND ACCUMULATOR TANK.
ELECTRIC POWER (92)	PROVIDES CLASS IE POWER TO SPECIAL SAFETY RELATED INSTRUMENTATION.
CONTROL BUILDING (77)	THE MAIN CONTROL ROOM AND REMOTE SHUTDOWN AREA HOUSE SPECIAL SAFETY RELATED INSTRUMENTATION.

C43

F-897(4)

GENERAL ATOMIC

SAFETY RELATED SYSTEMS
SYSTEM 32
NSS/BOP INTERFACES

SYSTEM IDENTITY	INTERFACE DESCRIPTION
CORE AUX. COOLING SYSTEM (CACS) (28)	PPS CACS INITIATE TO CACS SEQUENCER.
ELECTRIC POWER SYSTEM (92)	RECEIVES PPS SIGNAL TO OPEN CIRCUIT BREAKER TO MAIN CIRCULATOR MOTOR.
FEEDWATER (26)	NSS FLOW SENSOR IN BOP FEEDWATER LINE (ONE PER LOOP).
MAIN STEAM (52)	NSS RESISTANCE TEMPERATURE SENSOR (3 PER LOOP) IN BOP LINE. ALSO NSS PRESSURE TAP (3 PER LOOP) TO MEASURE MAIN STREAM PRESSURE.

C42

SAFETY RELATED SYSTEMS
SYSTEM 32
NSS/BOP INTERFACES

GENERAL ATOMIC

C41

SYSTEM IDENTITY	INTERFACE DESCRIPTION
FEEDWATER (26)	PPS AFFECTS CLOSURE OF FEEDWATER BLOCK AND TRIM VALVES, AND OPENS AND CLOSES STEAM HEADER DUMP VALVES.
CONTROL BUILDING (77)	THE MAIN CONTROL ROOM AND REMOTE SHUTDOWN AREA HOUSE PPS INSTRUMENT, CONTROL, AND ELECTRICAL EQUIPMENT.
TURBINE-GENERATOR CONTROL (51)	LOAD RUN-BACK ON REACTOR TRIP.

F-897(2)

GENERAL ATOMIC

SAFETY RELATED SYSTEMS
SYSTEM 32
NSS/BOP INTERFACES

SYSTEM IDENTITY	INTERFACE DESCRIPTION
MAIN STREAM (52)	RECEIVES PPS SIGNALS TO CLOSE MAIN SUPERHEATER OUTLET VALVES.
NON-CLASS IE AC POWER (92)	PROVIDES CONTROL ROD HOLDING POWER.
CLASS IE UPS AC POWER (92)	PROVIDES INSTRUMENT POWER TO PPS MEASUREMENT CHANNELS AND INITIATING LOGIC.

C40

F-897(1)

GENERAL ATOMIC

INTERFACES SYSTEM 32

SYSTEM	
11	PCRV
12	NEUTRON & REGION FLOW CONTROL
21	PRIMARY COOLANT, MAIN CIRCULATORS, STEAM GENERATORS
23	HELIUM PURIFICATION SYSTEM
28	CORE AUXILIARY COOLING SYSTEM
33	PLANT CONTROL SYSTEM
35	DATA ACQUISITION & PROCESSING
BOP	FEEDWATER, ELECTRICAL, T/G SET, VALVES, PNEUMATIC SYSTEM, HYDRAULIC SYSTEM, CONTAINMENT, ETC.

C39

F-867(2)

GENERAL ATOMIC

SAFETY RELATED SYSTEMS
SYSTEM 32
NSS/BOP INTERFACES

SYSTEM IDENTITY	INTERFACE DESCRIPTION
MAIN STREAM (52)	RECEIVES PPS SIGNALS TO CLOSE MAIN SUPERHEATER OUTLET VALVES.
NON-CLASS IE AC POWER (92)	PROVIDES CONTROL ROD HOLDING POWER.
CLASS IE UPS AC POWER (92)	PROVIDES INSTRUMENT POWER TO PPS MEASUREMENT CHANNELS AND INITIATING LOGIC.

C40

F-897(1)

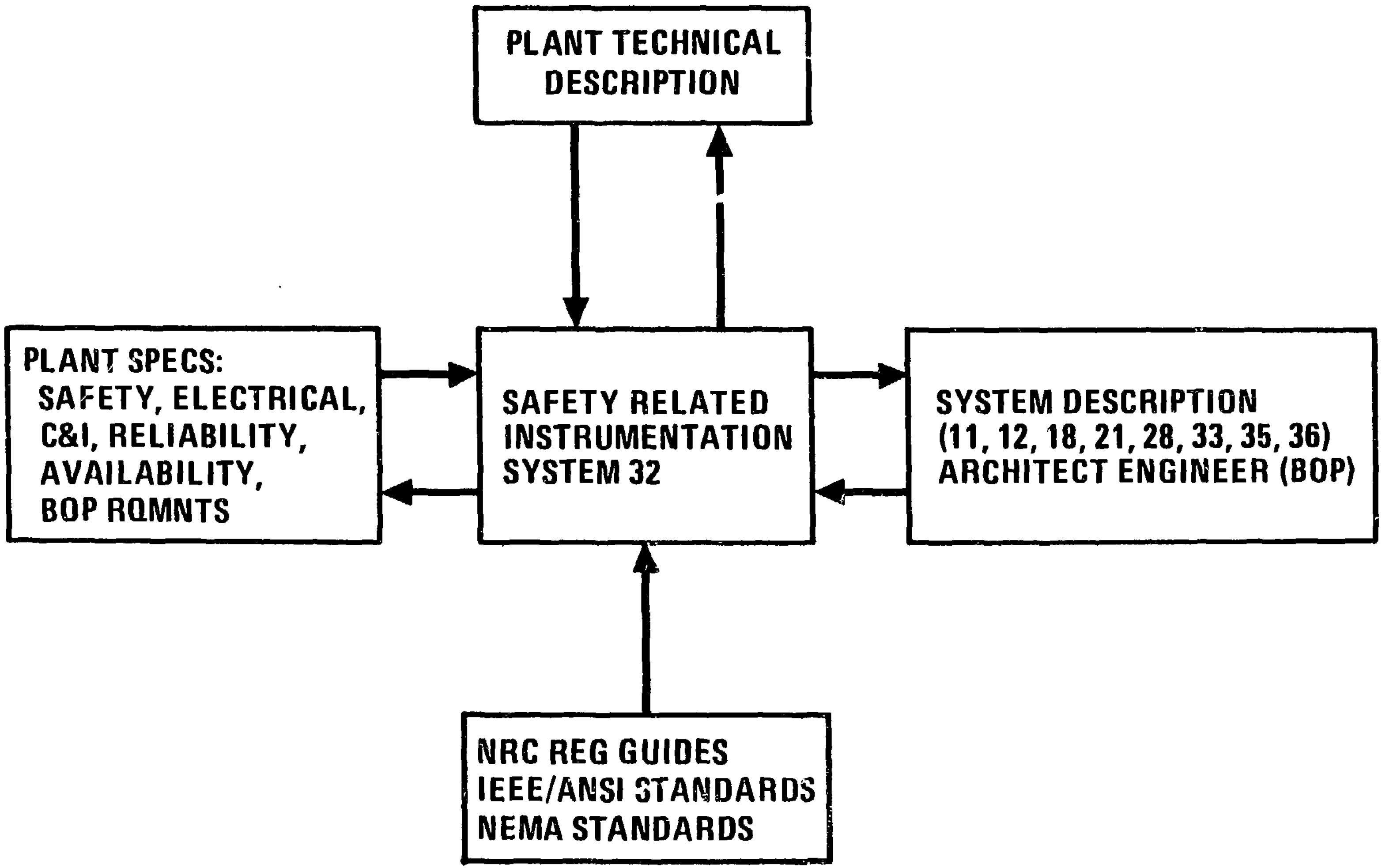
INTERFACES SYSTEM 32

SYSTEM	
11	PCRV
12	NEUTRON & REGION FLOW CONTROL
21	PRIMARY COOLANT, MAIN CIRCULATORS, STEAM GENERATORS
23	HELIUM PURIFICATION SYSTEM
28	CORE AUXILIARY COOLING SYSTEM
33	PLANT CONTROL SYSTEM
35	DATA ACQUISITION & PROCESSING
BOP	FEEDWATER, ELECTRICAL, T/G SET, VALVES, PNEUMATIC SYSTEM, HYDRAULIC SYSTEM, CONTAINMENT, ETC.

C39

F-867(2)

SAFETY RELATED INSTRUMENTATION DESIGN REQUIREMENTS



C38

F-868(1)

DESIGN OVERVIEW SYSTEM 32
SAFETY RELATED INSTRUMENTATION

C37

- 32-1 PLANT PROTECTION SYSTEM
- 32-2 MOISTURE MONITOR SYSTEM
- 32-3 SAFETY RELATED CONTROL AND INSTRUMENTATION SYSTEM

F-867(1)

GENERAL ATOMIC

C36

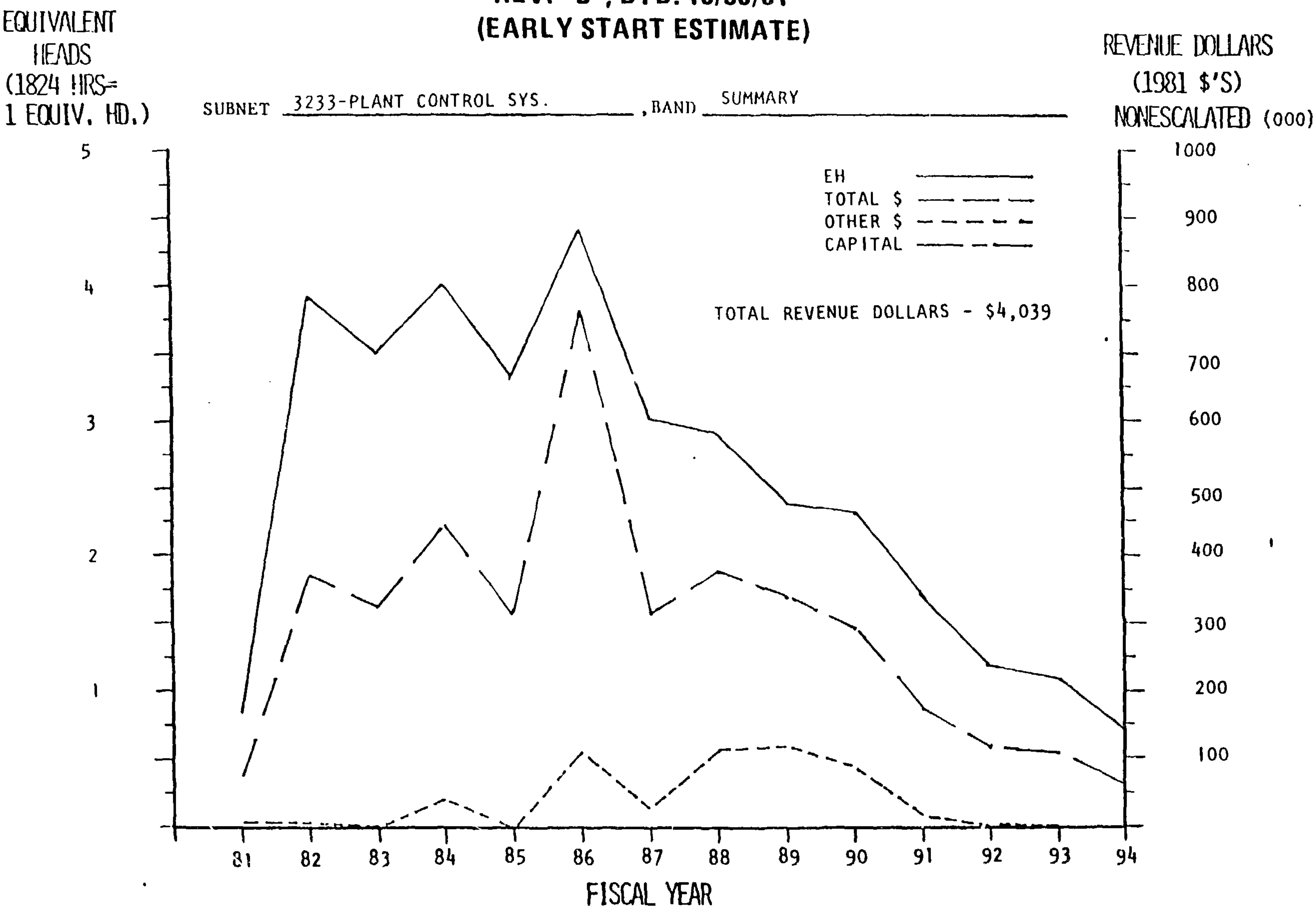
SAFETY RELATED INSTRUMENTATION

GENERAL ATOMIC COMPANY

GENERAL ATOMIC

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

SUBNET 3233-PLANT CONTROL SYS. , BAND SUMMARY



C35

NOTE ...RLY START - MANPOWER LOADING NOT YET OPTIMIZED/ ...L LOADED

GENERAL ATOMIC

OVERALL PLANT CONTROL SYSTEM

NEED	DESCRIPTION	PRIORITY	FACILITY	COST $(000)
2.33.B.1	DEVELOP HYBRID COMPUTER PROGRAMS FOR CONTROLS ANALYSIS	T2	NONE SPECIAL	355
2.33.C.1	DEVELOP OBSERVABILITY, CONTROLLABILITY AND HUMAN ENGINEERING CRITERIA	T2	NONE SPECIAL	46
2.33.D.1	DEVELOP MAIN CONTROL ROOM SIMULATOR AND ANALYSIS TO VERIFY COMPLIANCE WITH HUMAN ENGINEERING CRITERIA	T2 L1	FULL SCALE CONTROL ROOM SIMULATOR	10,000 (CAPITAL) 4,000 (LABOR)
2.33.D.2	VERIFY ADEQUATE LOGIC AND LAYOUT OF CONTROL AND PROTECTION SYSTEMS	T2 L1	FULL SCALE MOCK-UP OF BOARDS & CONSOLES	102
2.33.D.3	DEVELOP DATA BASE FOR ISOLATION DEVICES	T2	EXISTING GA ELECTRONIC LABS	46

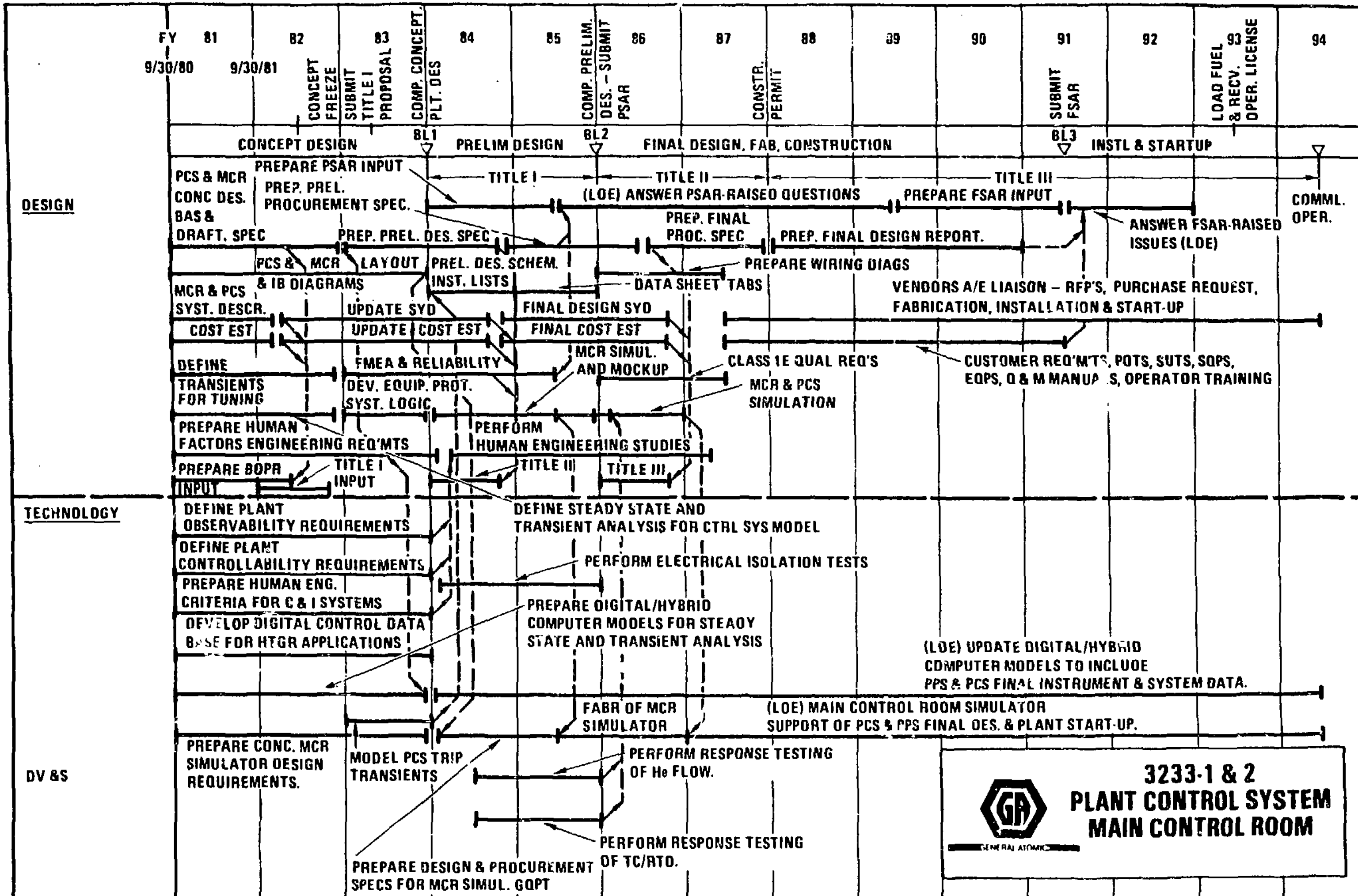
C34

F-899(2)

OVERALL PLANT CONTROL SYSTEM

ENCLOSURES, INSTRUMENTS, BOARDS, CONSOLES	PRICE ($000)
	1,500

C33


3233-1 & 2
PLANT CONTROL SYSTEM
MAIN CONTROL ROOM
GENERAL ATOMIC
FY 81 82 83 84 85 86 87 88 89 90 91 92 93 94
9/30/80
9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB, CONSTRUCTION
BL3
INSTL & STARTUP
DESIGN
TITLE I
TITLE II
TITLE III
PCS & MCR CONC DES. BAS & DRAFT. SPEC
PREPARE PSAR INPUT
PREP. PREL. PROCUREMENT SPEC.
(LOE) ANSWER PSAR-RAISED QUESTIONS
PREPARE FSAR INPUT
COMML. OPER.
PREP. FINAL PROC. SPEC
ANSWER FSAR-RAISED ISSUES (LOE)
PREP. PREL. DES. SPEC
PREP. FINAL DESIGN REPORT.
PCS & MCR LAYOUT
PREL. DES. SCHEM.
PREPARE WIRING DIAGS
& IB DIAGRAMS
INST. LISTS
DATA SHEET TABS
MCR & PCS SYST. DESCR.
VENDORS A/E LIAISON – RFP'S, PURCHASE REQUEST, FABRICATION, INSTALLATION & START-UP
UPDATE SYD
FINAL DESIGN SYD
COST EST
UPDATE COST EST
FINAL COST EST
DEFINE TRANSIENTS FOR TUNING
FMEA & RELIABILITY
MCR SIMUL. AND MOCKUP
CLASS 1E QUAL REQ'S
CUSTOMER REQ'M'TS, POTS, SUTS, SOPS, EOPS, O & M MANUALS, OPERATOR TRAINING
DEV. EQUIP. PROT. SYST. LOGIC
MCR & PCS SIMULATION
PREPARE HUMAN FACTORS ENGINEERING REQ'MTS
PERFORM HUMAN ENGINEERING STUDIES
PREPARE BOPR INPUT
TITLE I INPUT
TITLE II
TITLE III
TECHNOLOGY
DEFINE PLANT OBSERVABILITY REQUIREMENTS
DEFINE STEADY STATE AND TRANSIENT ANALYSIS FOR CTRL SYS MODEL
DEFINE PLANT CONTROLLABILITY REQUIREMENTS
PERFORM ELECTRICAL ISOLATION TESTS
PREPARE HUMAN ENG. CRITERIA FOR C & I SYSTEMS
DEVELOP DIGITAL CONTROL DATA BASE FOR HTGR APPLICATIONS
PREPARE DIGITAL/HYBRID COMPUTER MODELS FOR STEADY STATE AND TRANSIENT ANALYSIS
(LOE) UPDATE DIGITAL/HYBRID COMPUTER MODELS TO INCLUDE PPS & PCS FINAL INSTRUMENT & SYSTEM DATA.
FABR OF MCR SIMULATOR
(LOE) MAIN CONTROL ROOM SIMULATOR SUPPORT OF PCS & PPS FINAL DES. & PLANT START-UP.
DV &S
PREPARE CONC. MCR SIMULATOR DESIGN REQUIREMENTS.
MODEL PCS TRIP TRANSIENTS
PERFORM RESPONSE TESTING OF He FLOW.
PERFORM RESPONSE TESTING OF TC/RTD.
PREPARE DESIGN & PROCUREMENT SPECS FOR MCR SIMUL. GOPT

F-859(12)

GENERAL ATOMIC

OVERALL PLANT CONTROL SYSTEM DESIGN EVOLUTION

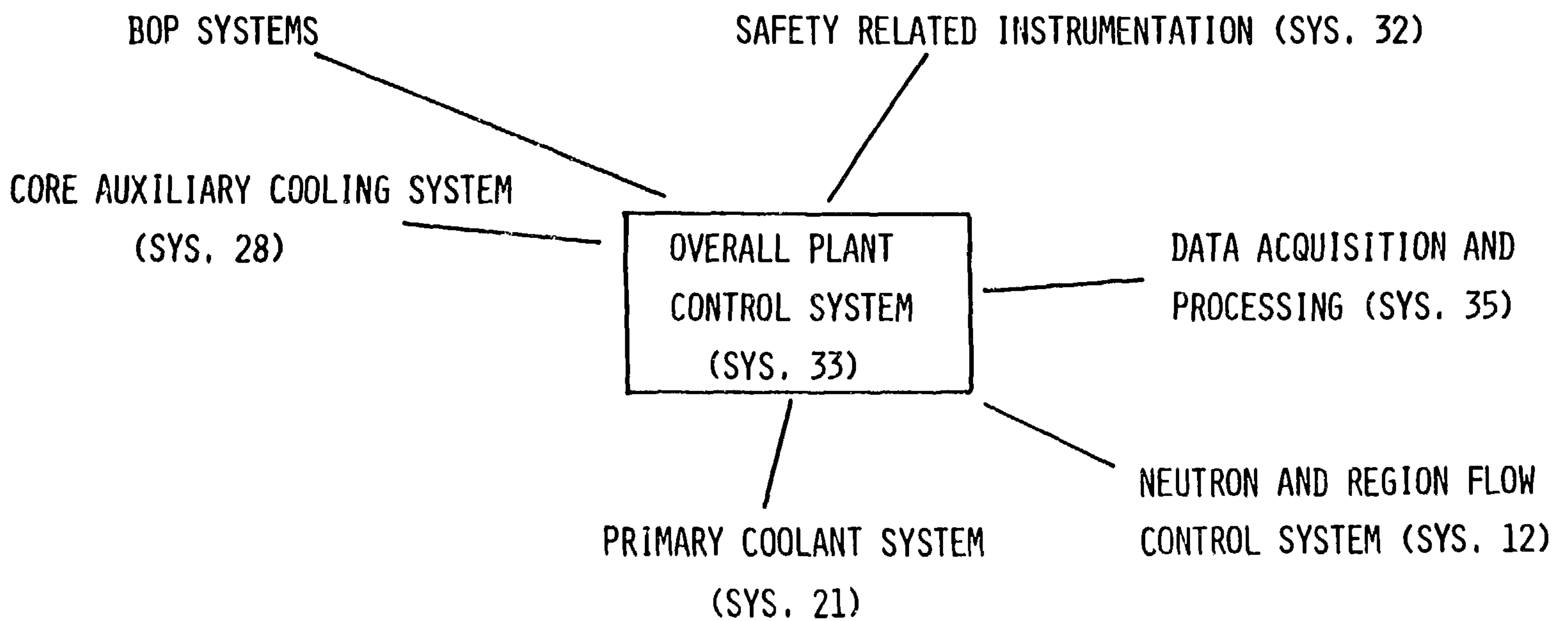
- STEAM PRESSURES CONTROLLED BY FEEDWATER FLOW – SIMILAR TO FSV, SUMMIT, FULTON, 900MWe REFERENCE HTGR
- STEAM TEMPERATURES CONTROLLED BY REACTOR POWER – SIMILAR TO FSV, SUMMIT, FULTON, 900MWe REFERENCE HTGR
- SEPARATE MAIN STEAM/HOT REHEAT TEMPERATURE CONTROL – ELIMINATED WITH THE ELIMINATION OF THE STEAM REHEATER – ONE DEGREE OF FREEDOM GAINED
- ELECTRICALLY DRIVEN CIRCULATOR – ELIMINATES STEAM – FEEDWATER INTERACTIONS, ENHANCES MAIN LOPP COOLING ABILITY
- HUMAN ENGINEERED CONTROL ROOMS AND BOARDS – ENHANCES PLANT AVAILABILITY

C31

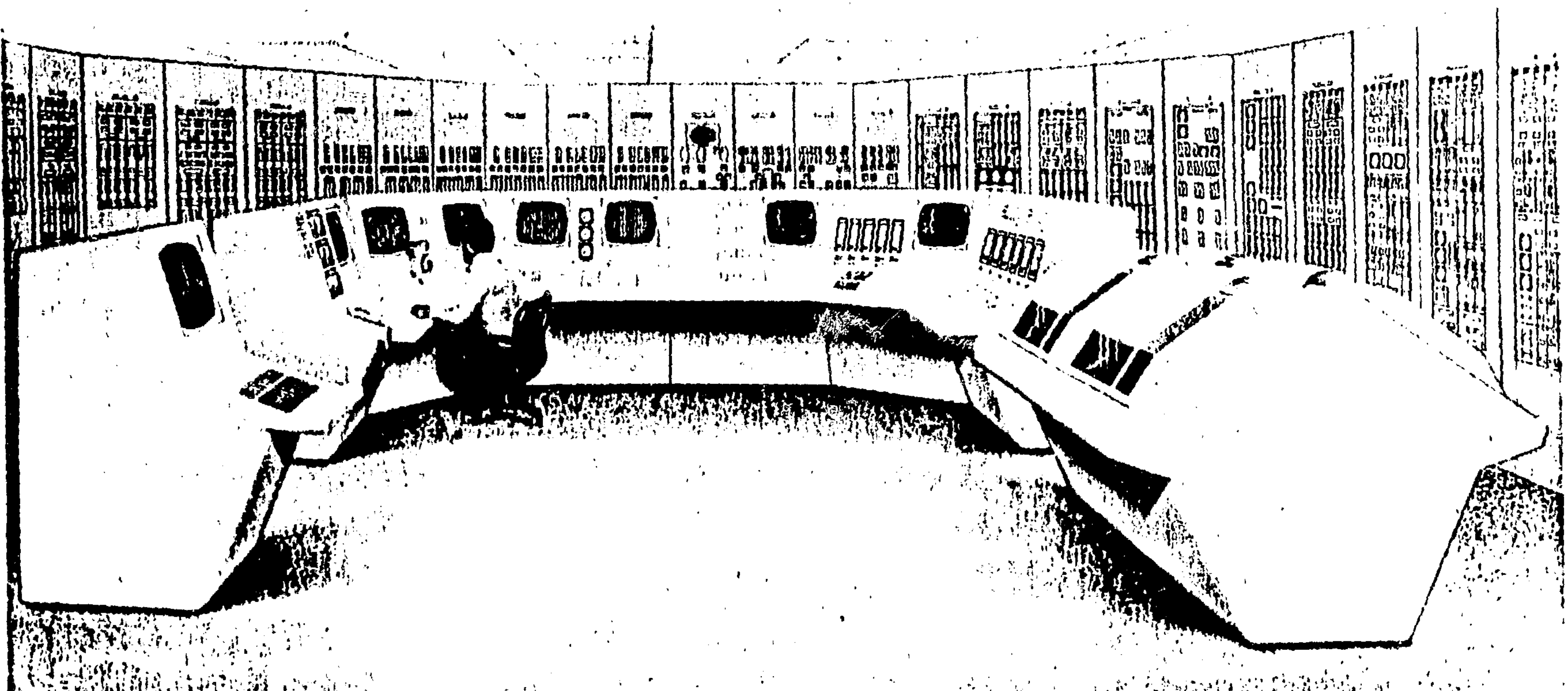
F-868(6)

OVERALL PLANT CONTROL SYSTEM

SYSTEM INTERFACES



C30



HTGR CONTROL CONSOLE

GENERAL ATOMIC

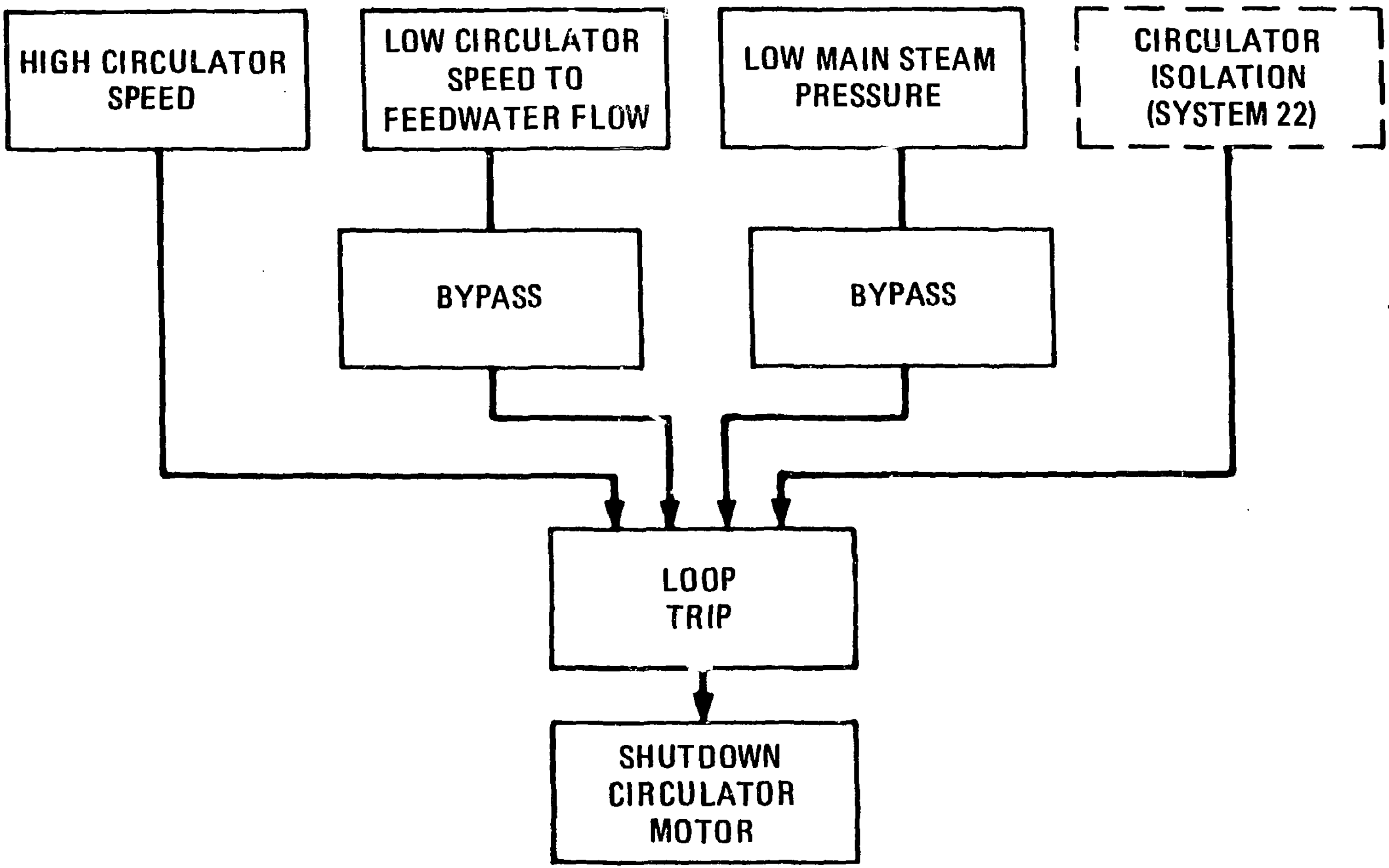
MAIN CIRCULATOR SERVICE SYSTEM ISOLATION

C28

SENSOR 1	LOW ΔP ACROSS HELIUM SUPPLY CAVITY AND HELIUM/WATER DRAIN CAVITY
SENSOR 2	LOW ΔP ACROSS HELIUM/WATER DRAIN CAVITY AND HIGH-PRESSURE JET PUMP SUPPLY
	LOW ΔP ACROSS BEARING WATER SUPPLY CAVITY AND BEARING WATER DRAIN
SENSOR 3	LOW ΔP ACROSS SEAL DRAIN CAVITY AND BEARING WATER DRAIN CAVITY

F-878(1)

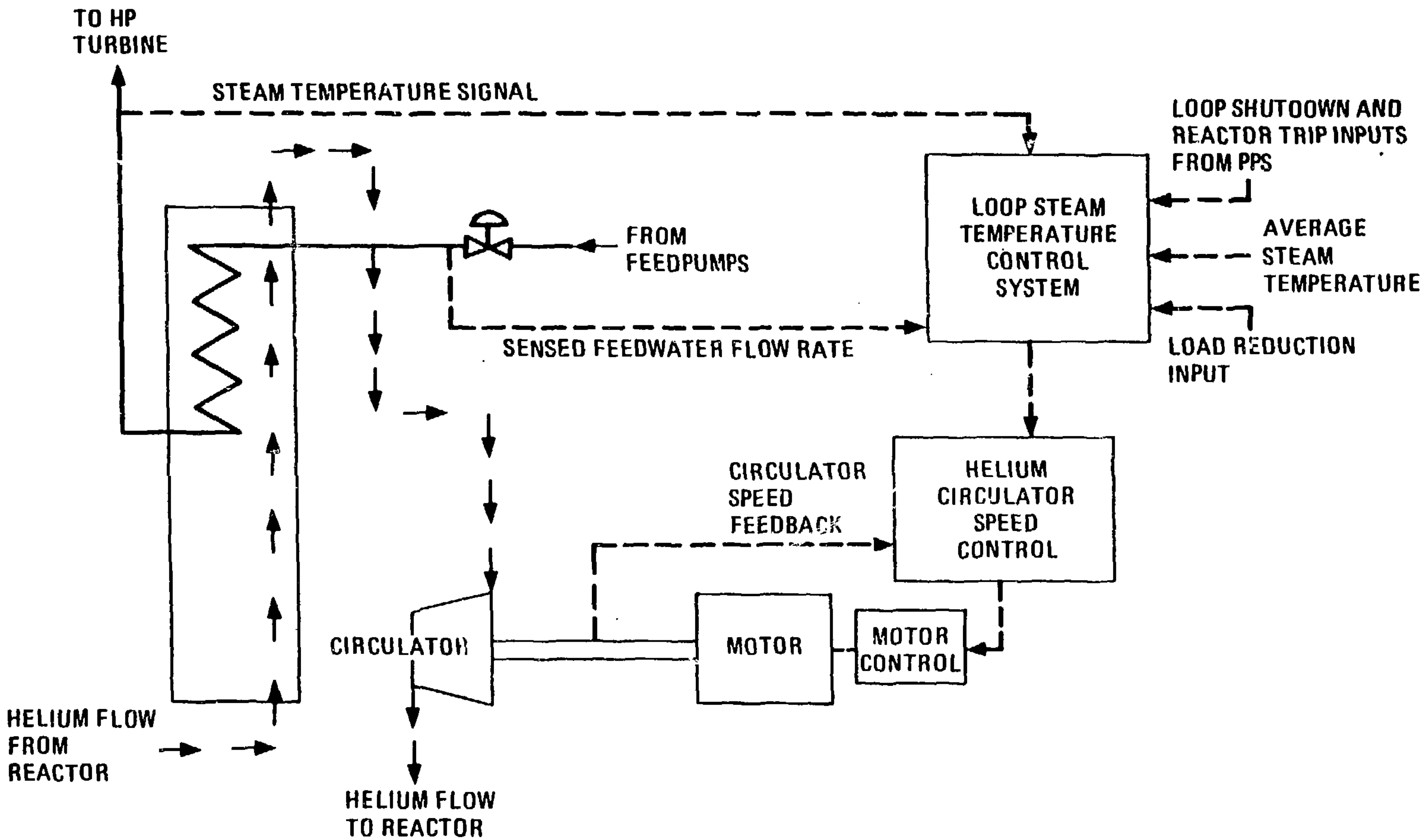
PLANT CONTROL SYSTEM LOOP TRIP



C27

F-878(6)

LOOP STEAM TEMPERATURE CONTROL

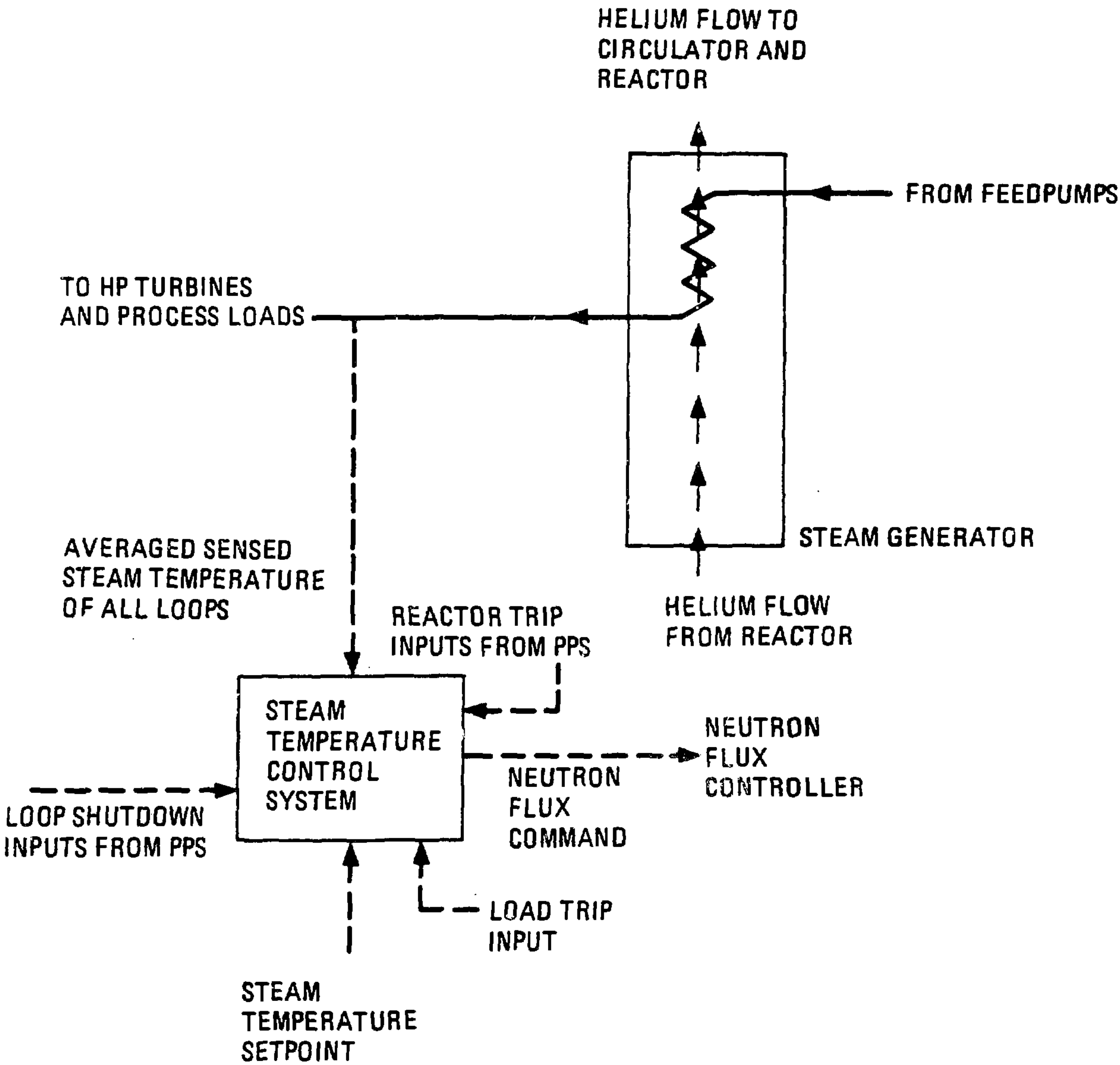


C26

F-878(3)

NEUTRON AND STEAM TEMPERATURE CONTROL

GENERAL ATOMIC



F-878(2)

GENERAL ATOMIC

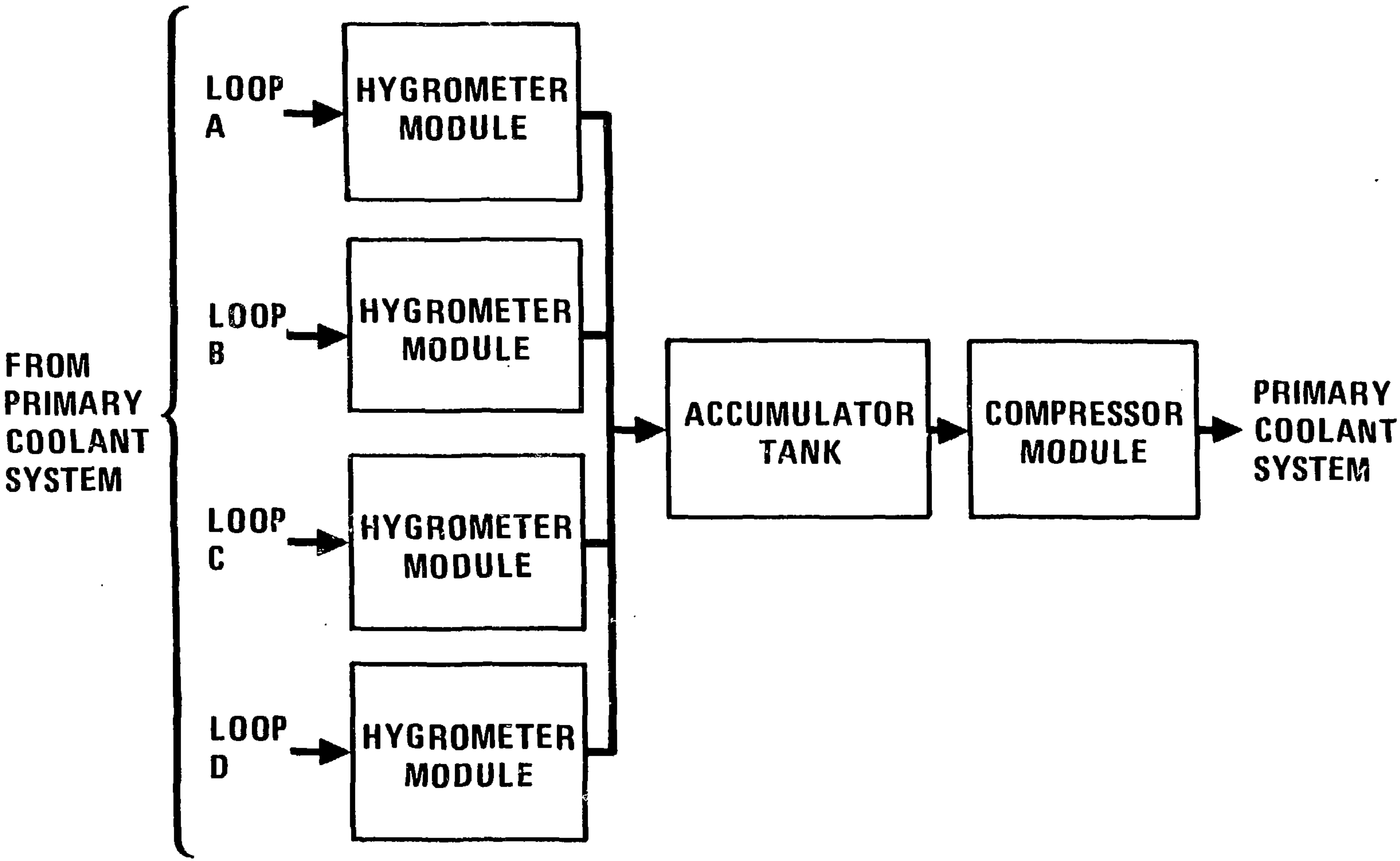
MOISTURE MONITOR SYSTEM
SYSTEM 32–2

- SAMPLES PRIMARY COOLANT FROM 4 S/G's
- DETECTS HIGH MOISTURE
- SIGNALS S/G ISOLATION & DUMP SYSTEM ON DETECTION OF LEAKING LOOP
- SIGNALS REACTOR TRIP SYSTEM ON DETECTION OF HIGH PRIMARY COOLANT MOISTURE

C65

F-867(22)

MOISTURE MONITORING SYSTEM—SCHEMATIC

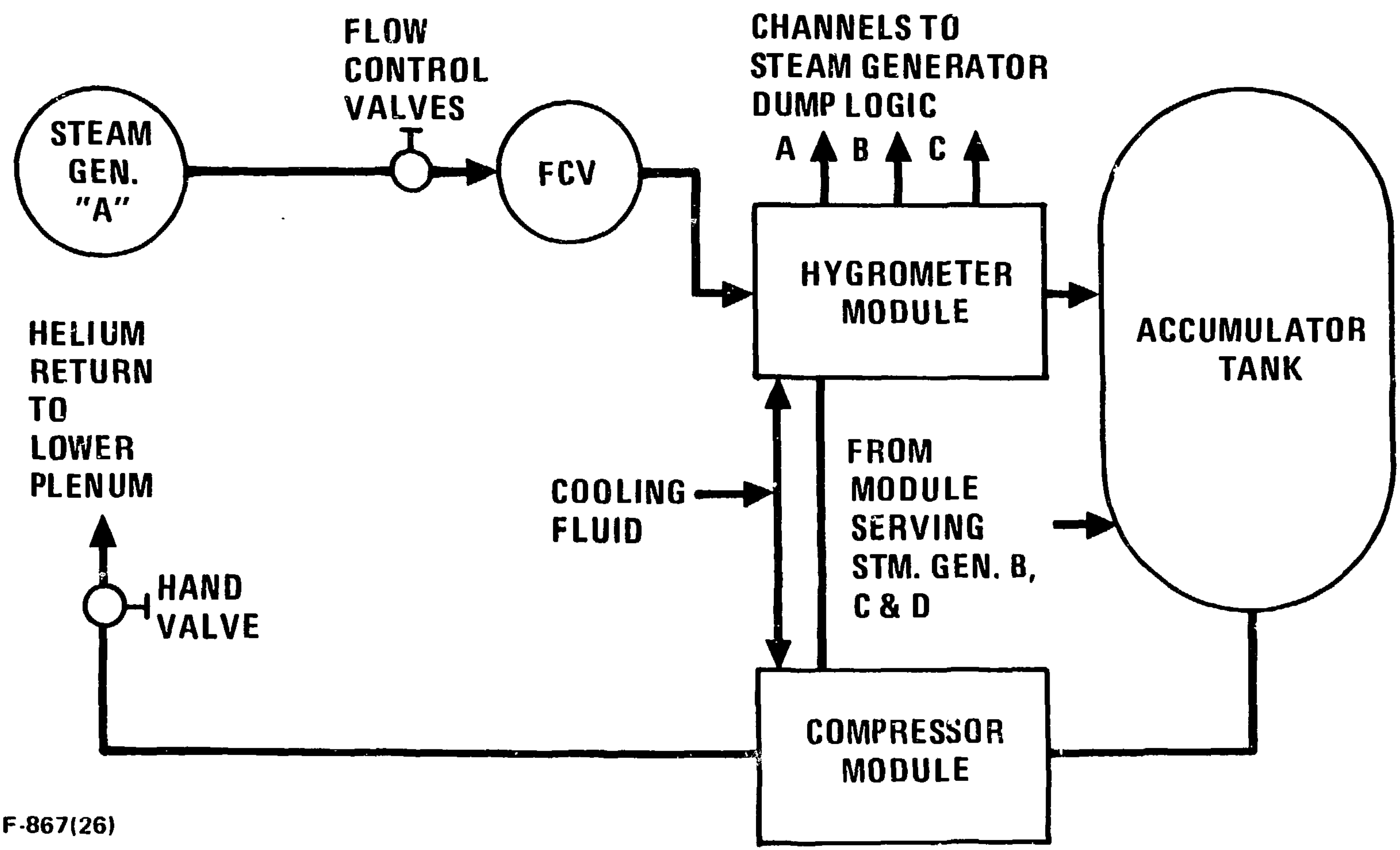


F-867(25)

C66

MOISTURE MONITOR SYSTEM

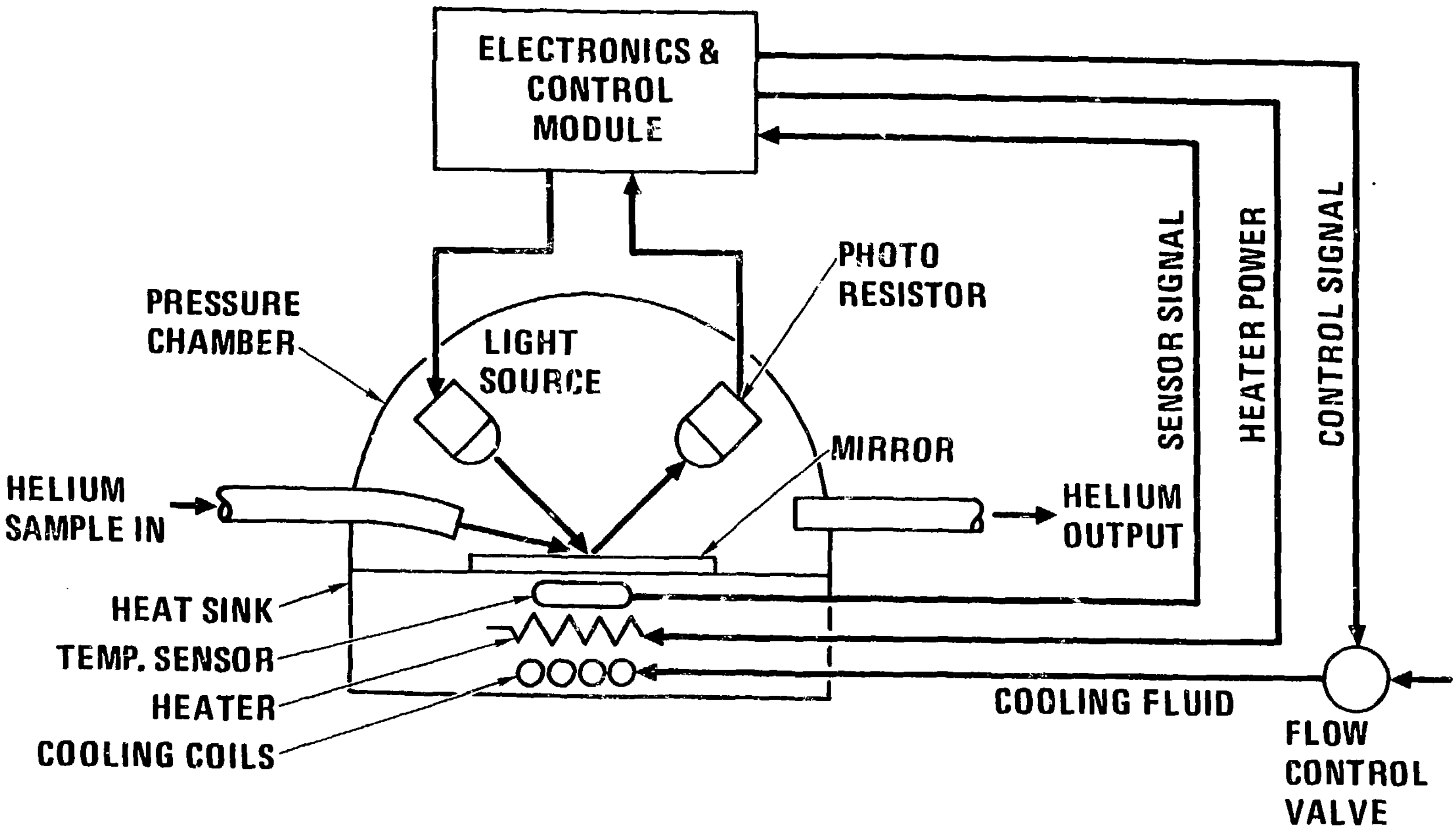
STEAM GENERATORS A SHOWN, STEAM GENERATORS B, C & D SAME



C67

F-867(26)

DEW POINT MOISTURE MONITOR INSTRUMENT OPERATION



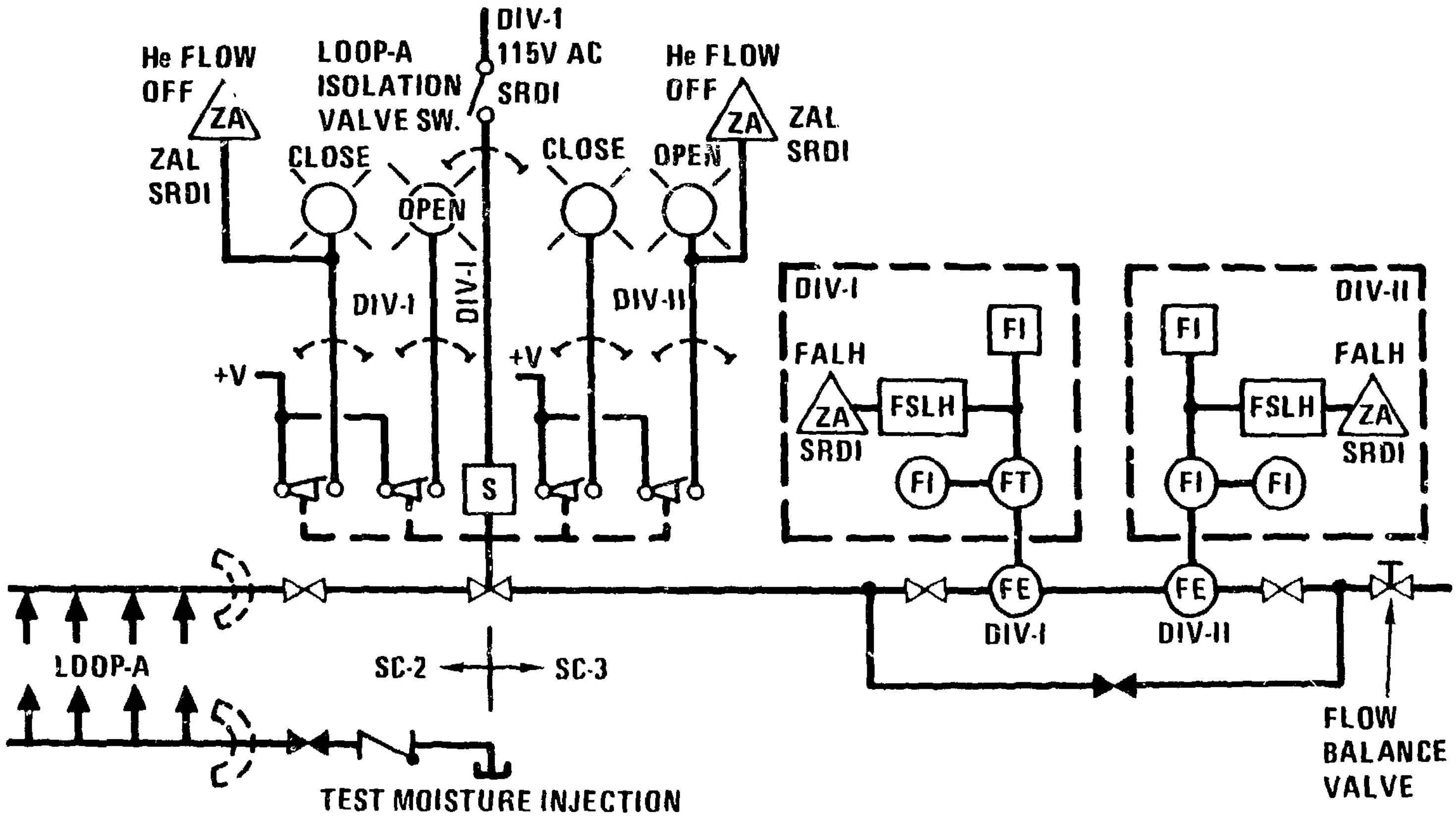
C68

F-867(27)

MOISTURE MONITOR SAMPLING SYSTEM

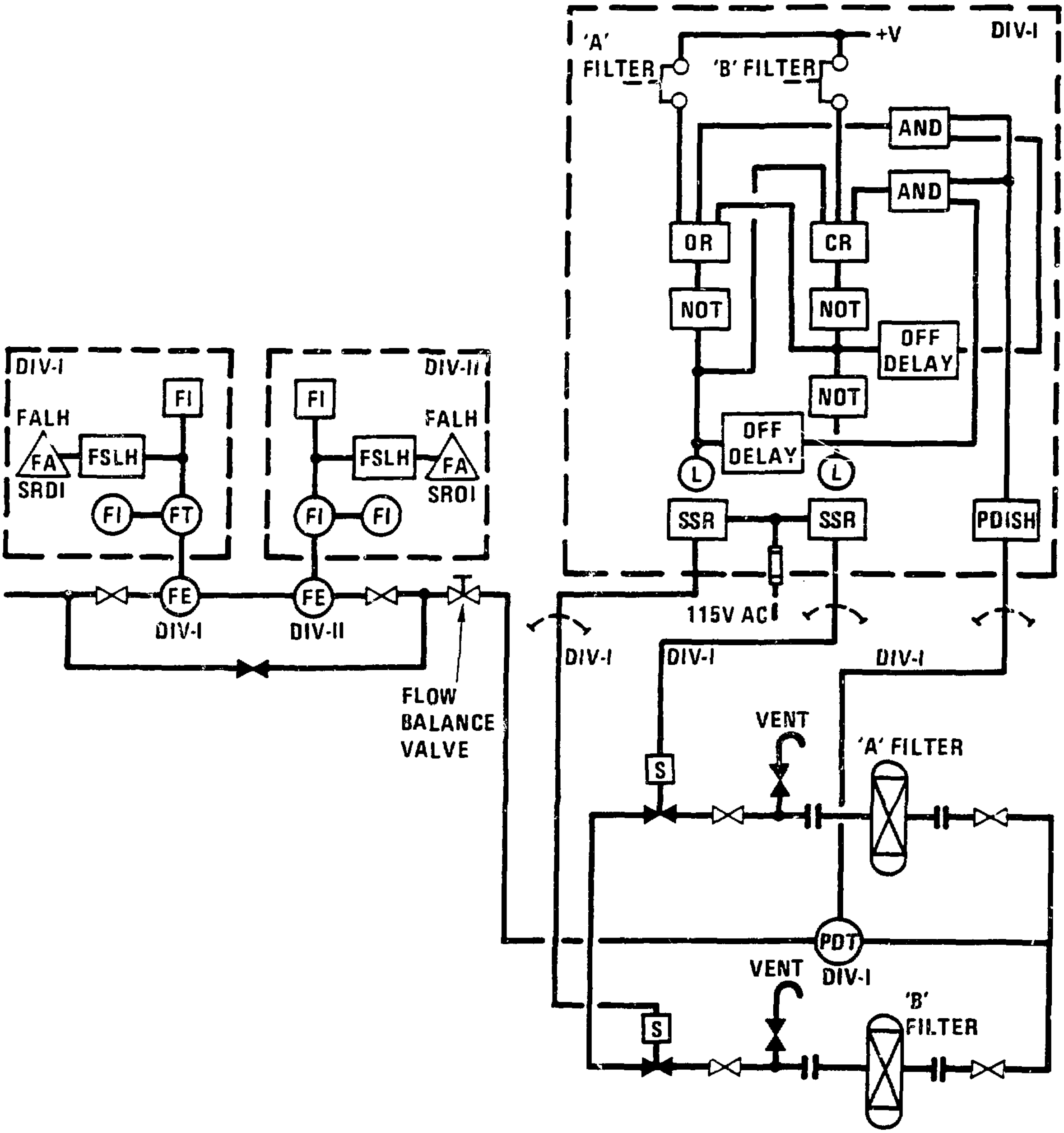
GENERAL ATOMIC

C69



F-867(28)

MOISTURE MONITOR FILTER SYSTEM



F-867(29)

MOISTURE MONITOR SYSTEM EVOLUTION FROM FSV

GENERAL ATOMIC

C71

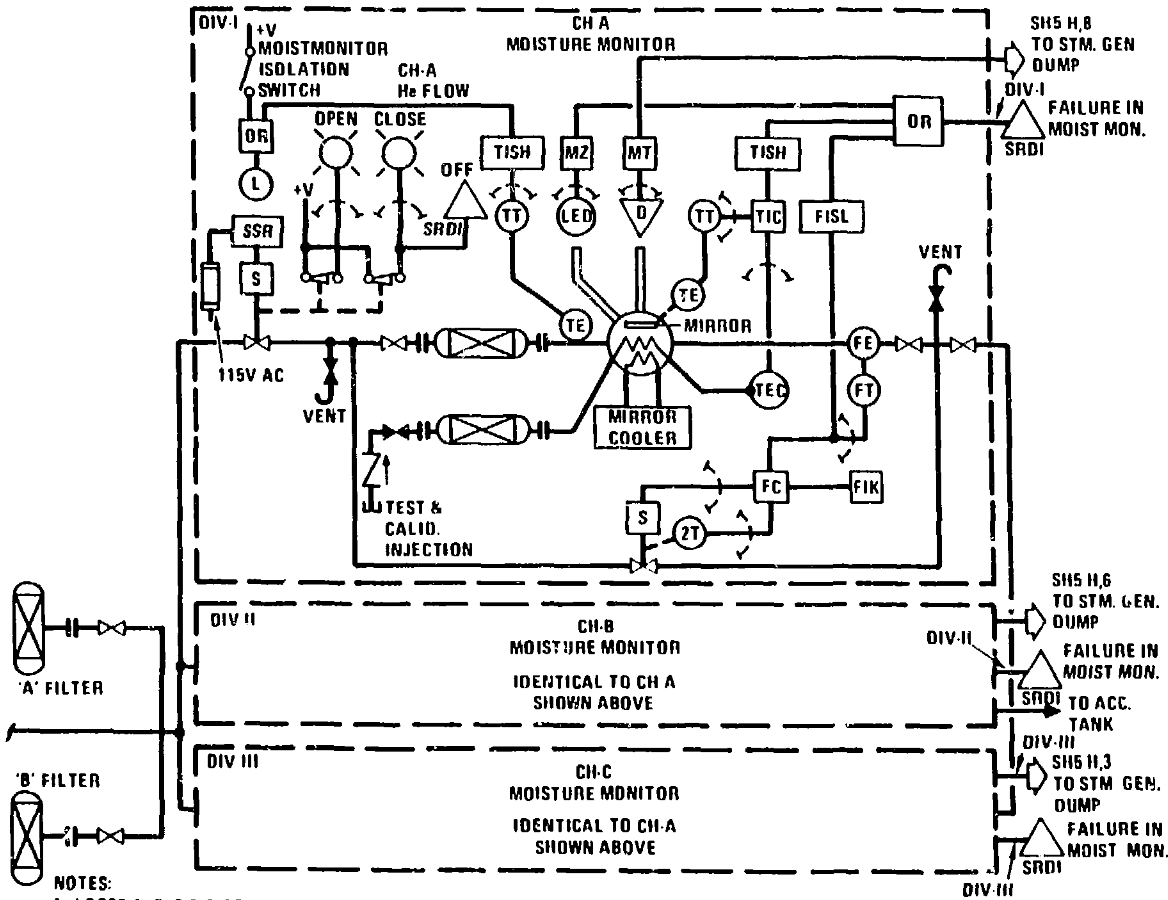
- SAMPLE DRIVEN BY COMPRESSORS IN SAMPLE LINE // CIRC ΔP USED AT FSV
- DETECTOR HEAD IMPROVEMENTS TO ELIMINATE MIRROR FOULING CONSIDERED (E.G. REMOTE CLEANING, CHEMICAL HYGROMETERS, FILTERS, ETC.)
- TEMPERATURE CONTROLLED SAMPLE LINES
- SIMPLIFIED ON-LINE TESTING & CALIBRATION (E.G. DETECTOR TEST SAMPLE INJECTION, TEMPERATURE/FLOW/LIGHT SOURCE MALFUNCTION DIAGNOSTICS, DIVERSE COMPARISON MONITOR, ETC.)

F-867(24)

MOISTURE MONITOR DETECTOR SYSTEM

GENERAL ATOMIC

C72



NOTES:
1. LOOPS A, B, C & D ARE IDENTICAL TO LOOP SHOWN ON THIS DRAWING.

F-867(30)

SPECIAL SAFETY RELATED SYSTEMS
SYSTEM 32–3

GENERAL ATOMIC

- SAFETY RELATED DISPLAY INSTRUMENTATION (SRDI)
- POST ACCIDENT MONITORING INSTRUMENTATION (PAM)
- CORE PERFORMANCE INSTRUMENTATION (CPI)

SYSTEMS THAT PERFORM FUNCTIONS RELATED TO SAFETY BUT ARE NOT SAFETY SYSTEMS.

C73

GENERAL ATOMIC

SRDI

OBJECTIVE: SUFFICIENT INFORMATION TO ENABLE OPERATOR TO VERIFY SAFETY FUNCTIONS.

- DISPLAYS EACH VARIABLE RELATED TO PLANT SAFETY
- INDICATES SAFETY SYSTEM LOGIC STATUS
- INDICATES SAFETY SYSTEM ACTUATED DEVICE POSITION OR STATUS

ACTIVE DURING NORMAL OPERATION, DURING AND AFTER ACCIDENTS.

C74

PAM

OBJECTIVE: ENABLE OPERATOR TO FOLLOW ACCIDENTS

- MONITORS & RECORDS PLANT VARIABLES & SYSTEM CONDITIONS DURING & FOLLOWING AN ACCIDENT
- SUBSET OF SRDI

C75

MOST NEEDED SYSTEM CONDITIONS:

REACTOR SHUTDOWN
CORE COOLING
CONTAINMENT ISOLATION
CONTAINMENT PRESSURE
PRIMARY COOLANT PRESSURE
HEAT TRANSFER FROM CORE TO HEAT SINK

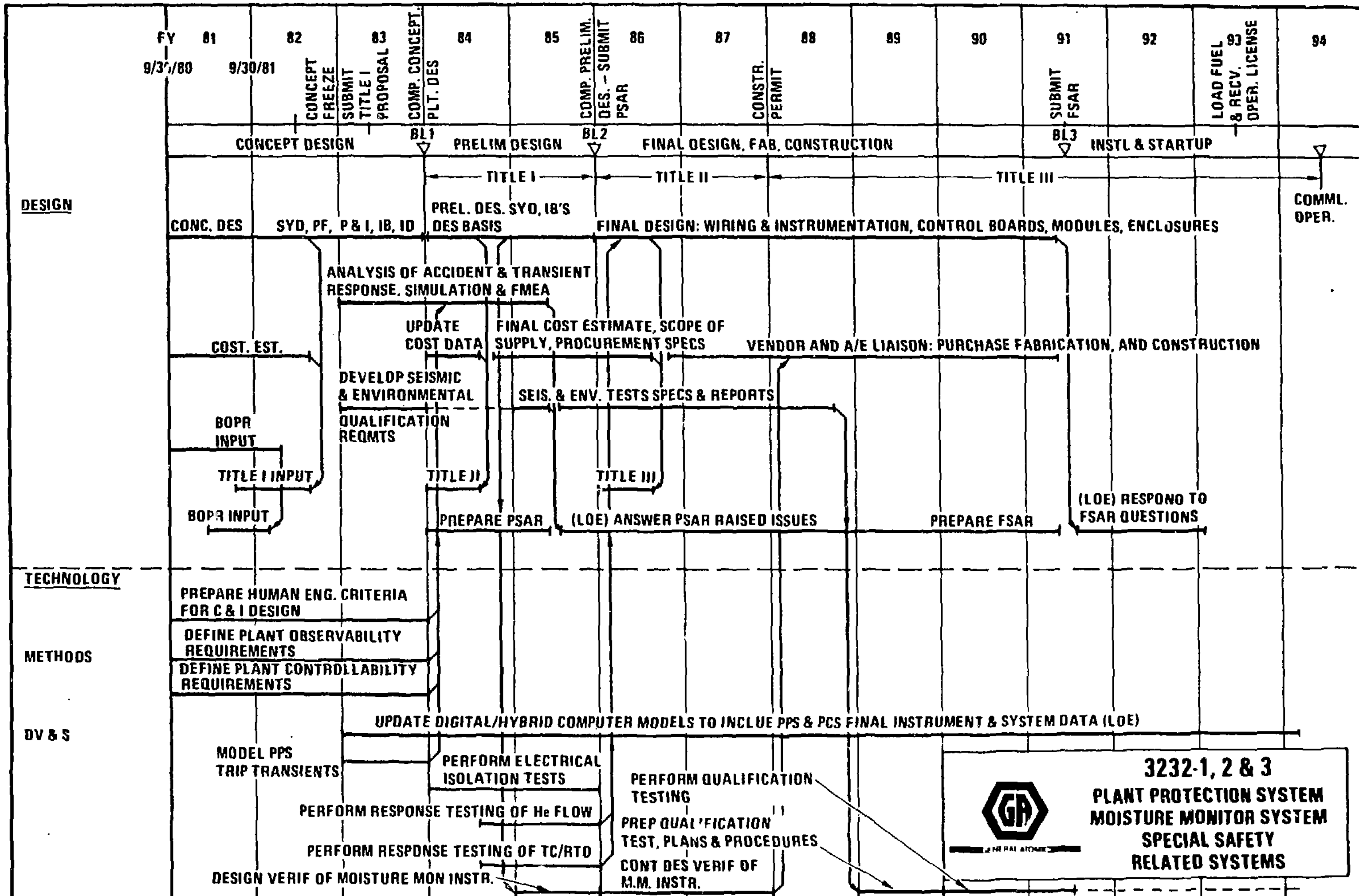
GENERAL ATOMIC

CPI

OBJECTIVE: PROVIDE OPERATOR WITH INFORMATION NEEDED TO PREVENT EXCEEDING CORE LCO's.

- MONITORS OVERALL CORE PERFORMANCE
- VERIFIES COMPLIANCE WITH LIMITING CONDITIONS FOR OPERATION (LCO's)
- SUBSET OF SRDI

C76


FY 81 82 83 84 85 86 87 88 89 90 91 92 93 94
9/30/80 9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB. CONSTRUCTION
BL3
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
COMML. OPER.
DESIGN
CONC. DES
SYD, PF, P & I, IB, ID
PREL. DES. SYD, IB'S DES BASIS
FINAL DESIGN: WIRING & INSTRUMENTATION, CONTROL BOARDS, MODULES, ENCLOSURES
ANALYSIS OF ACCIDENT & TRANSIENT RESPONSE, SIMULATION & FMEA
COST. EST.
UPDATE COST DATA
FINAL COST ESTIMATE, SCOPE OF SUPPLY, PROCUREMENT SPECS
VENDOR AND A/E LIAISON: PURCHASE FABRICATION, AND CONSTRUCTION
DEVELOP SEISMIC & ENVIRONMENTAL QUALIFICATION REQMTS
SEIS. & ENV. TESTS SPECS & REPORTS
BOPR INPUT
TITLE I INPUT
TITLE II
TITLE III
BOPR INPUT
PREPARE PSAR
(LOE) ANSWER PSAR RAISED ISSUES
PREPARE FSAR
(LOE) RESPOND TO FSAR QUESTIONS
TECHNOLOGY
METHODS
PREPARE HUMAN ENG. CRITERIA FOR C & I DESIGN
DEFINE PLANT OBSERVABILITY REQUIREMENTS
DEFINE PLANT CONTROLLABILITY REQUIREMENTS
DV & S
UPDATE DIGITAL/HYBRID COMPUTER MODELS TO INCLUE PPS & PCS FINAL INSTRUMENT & SYSTEM DATA (LOE)
MODEL PPS TRIP TRANSIENTS
PERFORM ELECTRICAL ISOLATION TESTS
PERFORM RESPONSE TESTING OF He FLOW
PERFORM RESPONSE TESTING OF TC/RTD
DESIGN VERIF OF MOISTURE MON INSTR.
PERFORM QUALIFICATION TESTING
PREP QUALIFICATION TEST, PLANS & PROCEDURES
CONT DES VERIF OF M.M. INSTR.
3232-1, 2 & 3
PLANT PROTECTION SYSTEM
MOISTURE MONITOR SYSTEM
SPECIAL SAFETY RELATED SYSTEMS

F-859(11)

GENERAL ATOMIC

SAFETY RELATED INSTRUMENTATION, SYSTEM 32

DESIGN DATA NEEDS

NEED	DESCRIPTION	PRIORITY	FACILITY	REVISED COST $(000)
2.32.D.1	VERIFY MOISTURE MONITOR RESPONSE AND REPEATABILITY	T2	EXISTING CONTROL, ELECTRICAL, ELECTRONICS & EXPERIMENTAL ENGINEERING FACILITIES	51
2.32.D.2	VERIFY SENSITIVITY, RESOLUTION AND REPEATABILITY OF HELIUM MASS FLOW MEASUREMENT	L1	EXISTING CONTROL, ELECTRICAL, ELECTRONICS & EXPERIMENTAL ENGINEERING FACILITIES	150
2.32.D.3	VERIFY THE TECHNICAL FEASIBILITY, SENSITIVITY, RESOLUTION AND REPEATABILITY OF STEAM GENERATOR INLET TEMPERATURE INSTRUMENTATION, INCLUDING THE STEAM GENERATOR INLET TEMPERATURE RAKE.	L1	EXISTING CONTROL, ELECTRICAL, ELECTRONICS & EXPERIMENTAL ENGINEERING FACILITIES	150

C78

1 - ESSENTIAL
2 - RISK REDUCTION
3 - OPTIMIZATION/APPLICATION ENHANCEMENT

T - TECHNICAL
L - LICENSING
E - ECONOMICS

GENERAL ATOMIC

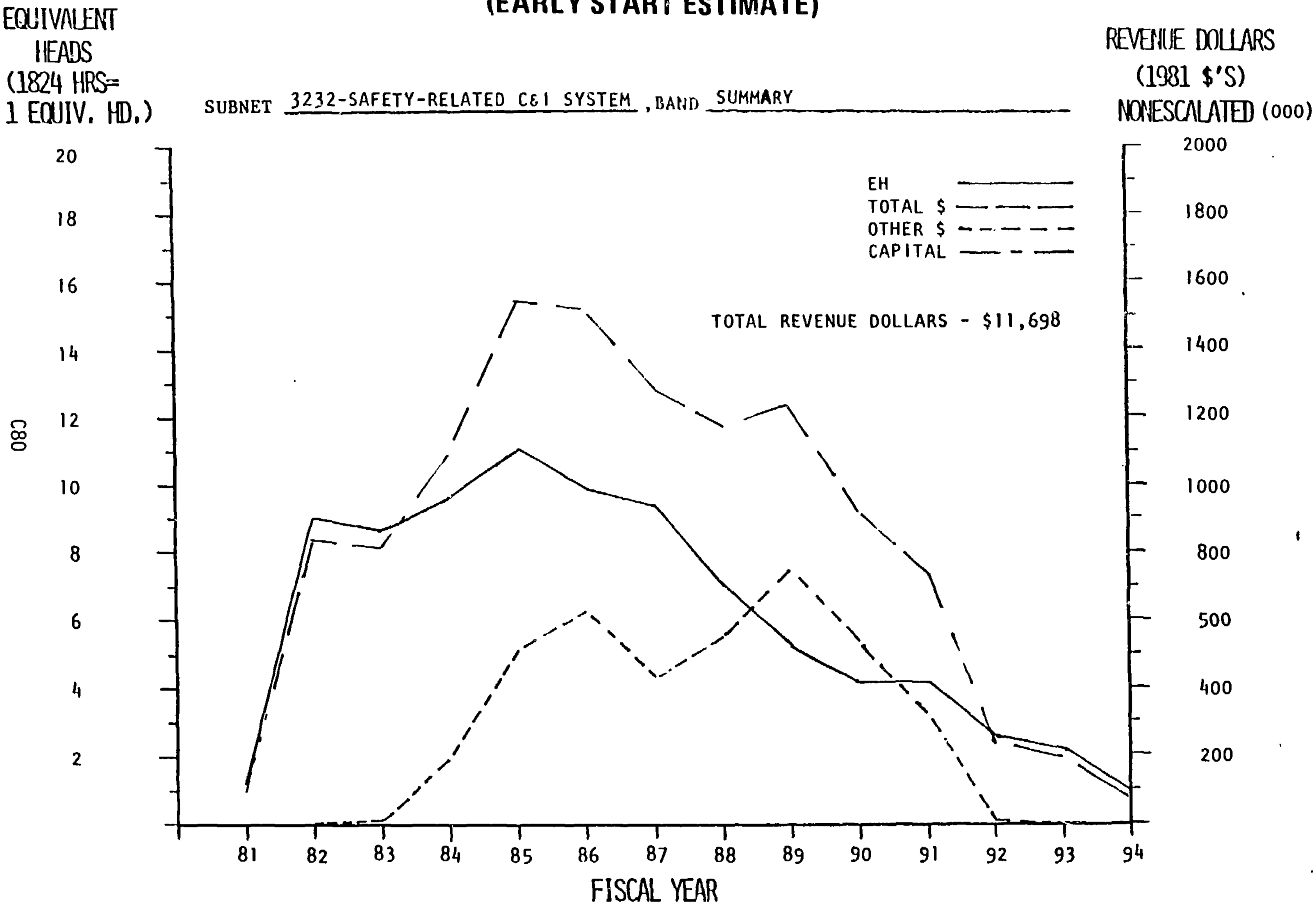
SAFETY RELATED INSTRUMENTATION, SYSTEM 32

DESIGN DATA NEEDS

NEED	DESCRIPTION	PRIORITY	FACILITY	REVISED COST $(000)
2.32.D.4	EQUIPMENT QUALIFICATION	T2	EXISTING CONTROL, ELECTRICAL, ELECTRONICS & EXPERIMENTAL ENGINEERING FACILITIES, SUBCONTRACTOR FACILITIES.	1950
2.33.D.1	PERFORM HUMAN ENGINEERING STUDIES TO LOCAL AND REMOTE CONTROL SCHEMES, AND MAIN CONTROL ROOM AND REMOTE SHUTDOWN ROOM ARRANGEMENT AND FEATURES AS REQUIRED TO ASSURE THAT PLANT OPERATION CAN BE PROPERLY MONITORED AND CONTROLLED BY OPERATING PERSONNEL.	T2 L1	FULL SCALE CONTROL ROOM SIMULATION WITH INTERFACE CAPABILITIES TO CONNECT EXPERIMENTAL COMPONENT TEST FACILITIES AND REAL TIME COMPUTER SIMULATION LABORATORY.	SEE PCS DDN's
2.33.D.2	VERIFY ADEQUATE LOGIC AND LAYOUT OF PPS & PCS	T2 L1	FULL SCALE MOCK-UP OF CONTROL ROOM BOARDS AND CONSOLES	SEE PCS DDN's
2.33.D.3	DEVELOP DATA BASE FOR SOLID STATE AND FIBER OPTIC COMPONENTS	T2	EXISTING ELECTRONIC LABORATORIES	SEE PCS DDN's

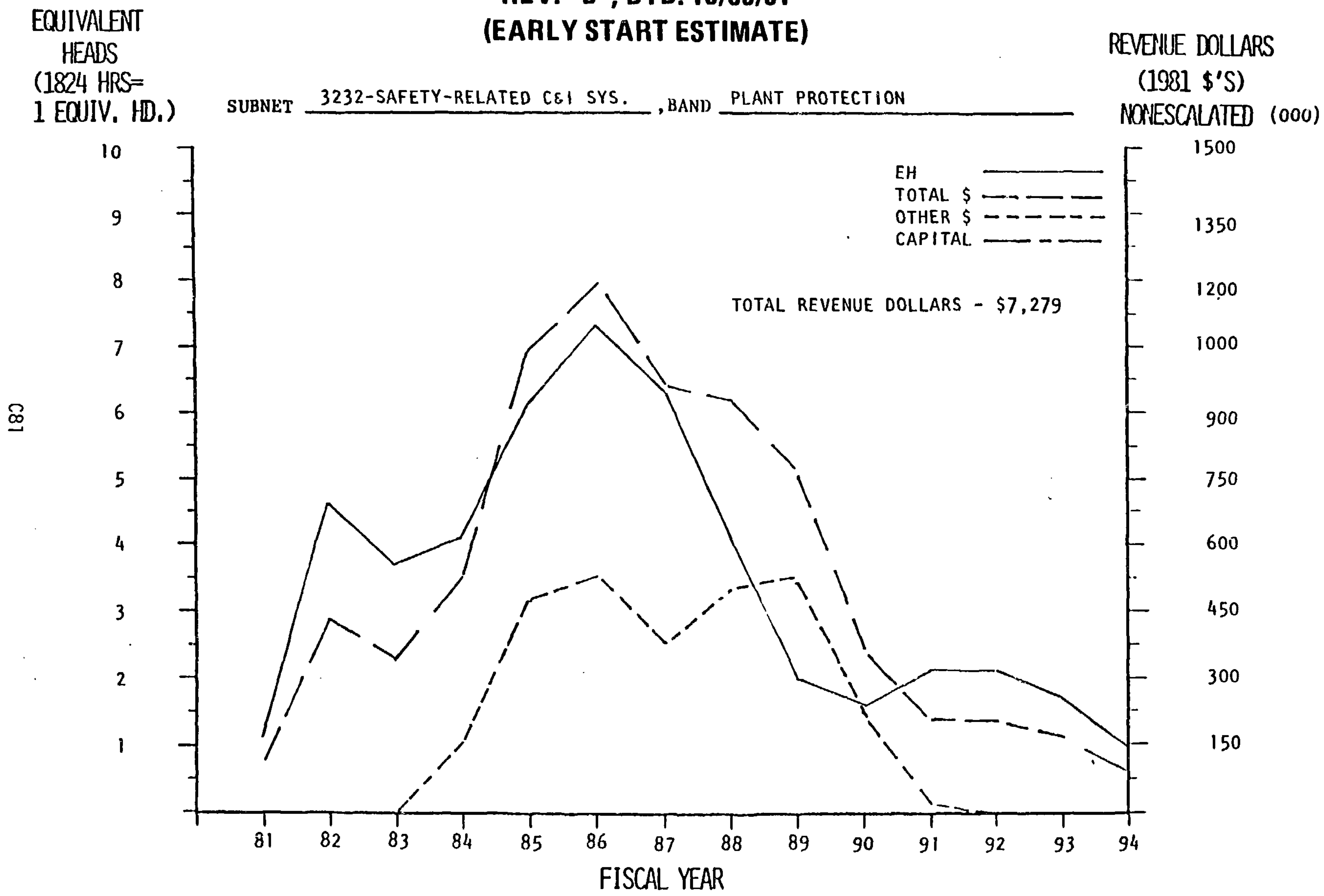
C79

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)



NOTE RLY START - MANPOWER LOADING NOT YET OPTIMIZED/ I LOADED

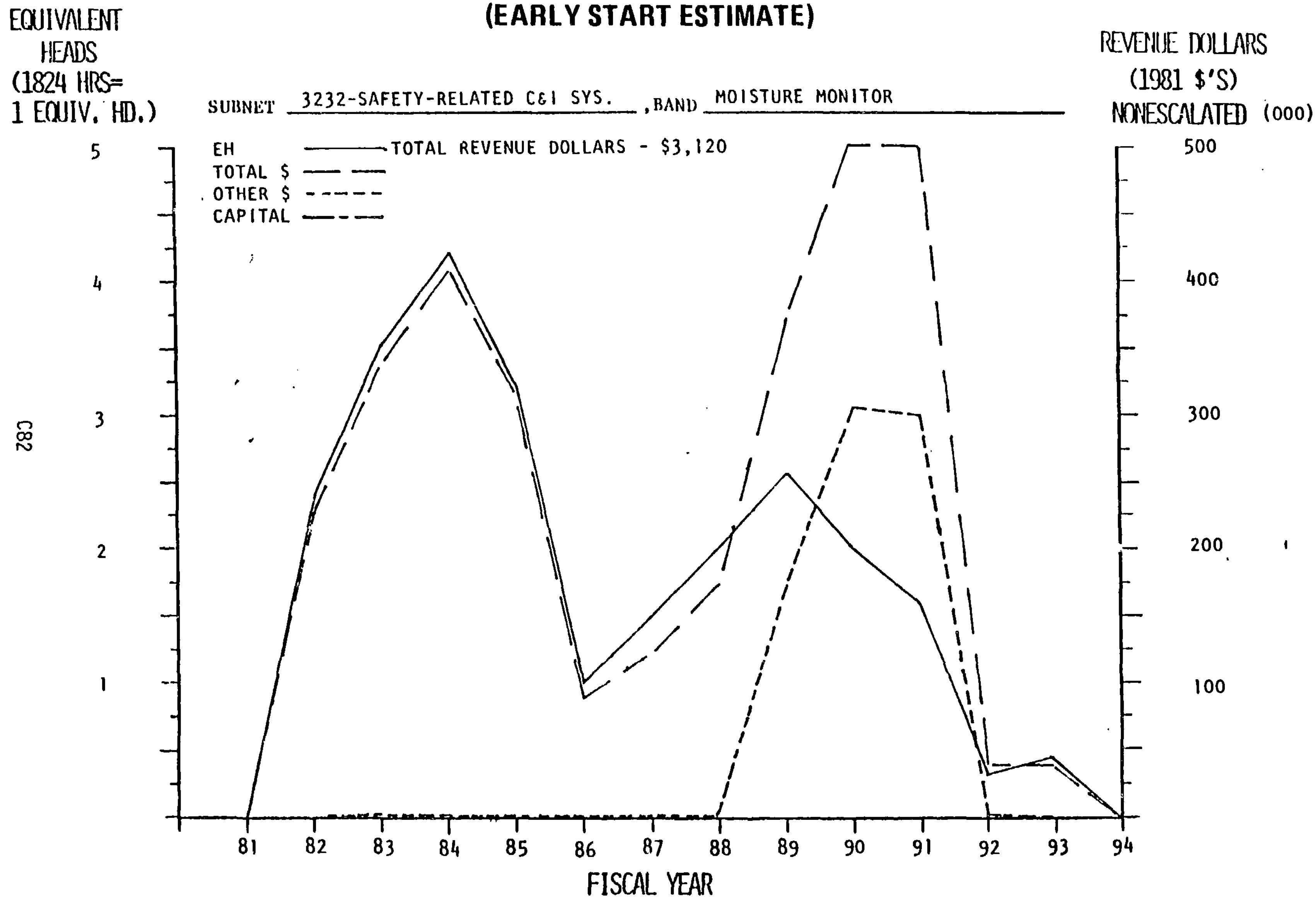
HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)



NOTE: EARLY START - MANPOWER LOADING NOT YET OPTIMIZED/LEVEL LOADED

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

SUBNET 3232-SAFETY-RELATED C&I SYS. , BAND MOISTURE MONITOR

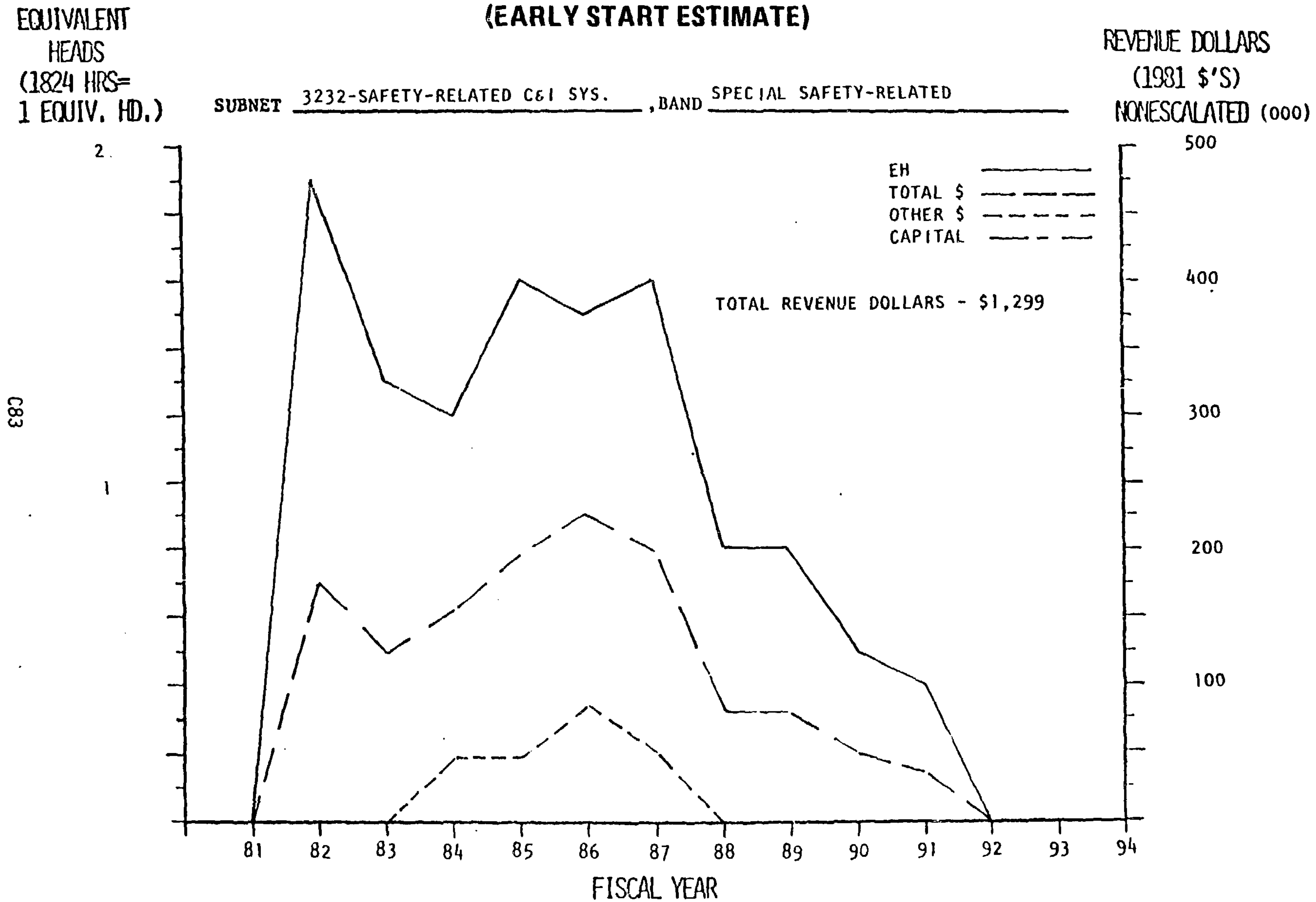


282

NOTE RLY START - MANPOWER LOADING NOT YET OPTIMIZED/ LOADED

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

SUBNET 3232-SAFETY-RELATED C&I SYS. , BAND SPECIAL SAFETY-RELATED



NOTE: EARLY START - MANPOWER LOADING NOT YET OPTIMIZED/LEVEL LOADED

GENERAL ATOMIC

SAFETY RELATED SYSTEM, SYSTEM 32, PRICES

C84

PPS INST. ENCLOSURES	(10^6)
PPS INST/HDW	3.5
PPS CONTROL BOARDS	
MOISTURE MONITOR HYGROMETER MODULE	
MOISTURE MONITOR COMPRESSOR MODULE	
MOISTUREMONITOR ACCUMULATOR TANK	
MOISTURE MONITOR INST ENCLOSURES	2.7
MOISTURE MONITOR INST/HDW	
MOISTURE MONITOR NON-MODULE EQUIPMENT	
TOTAL	6.2

F-897(5)

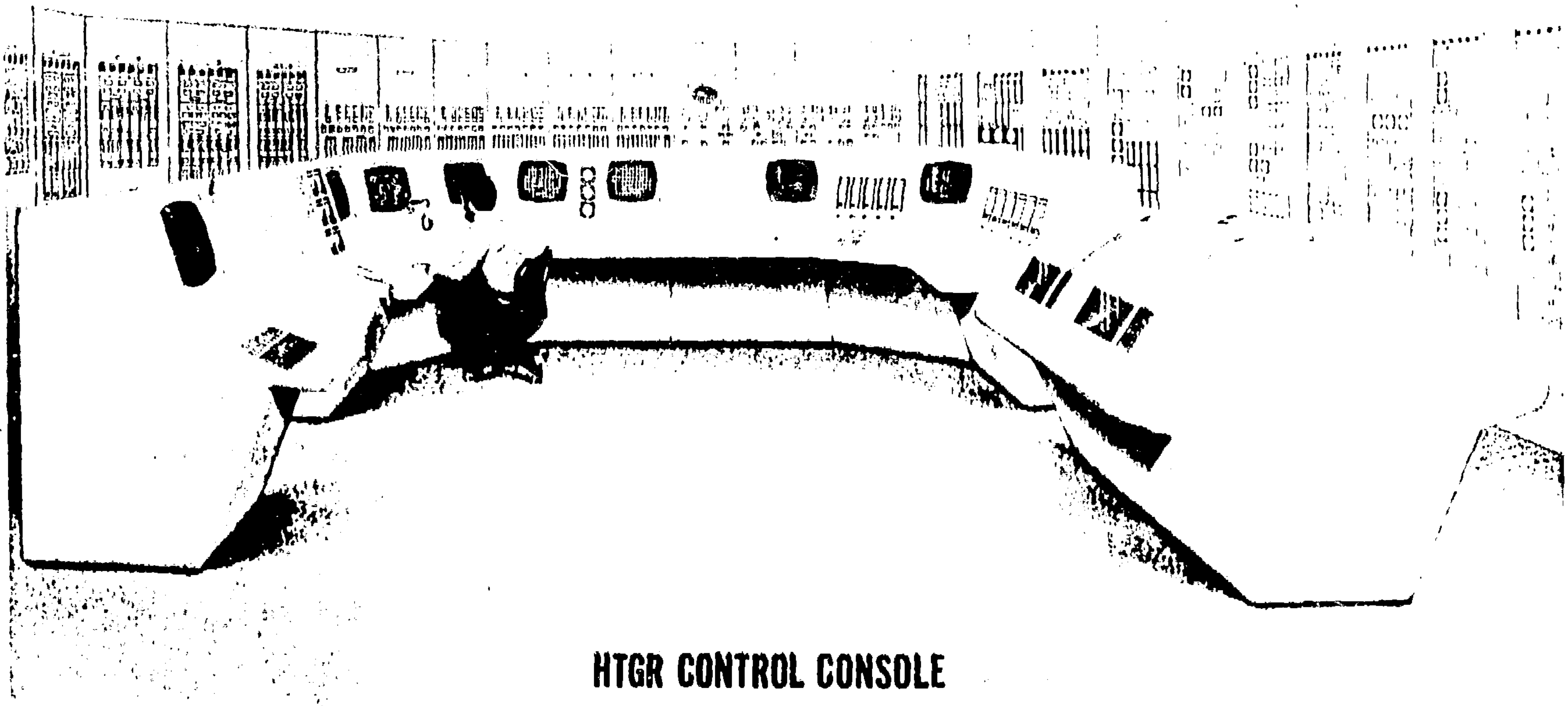
GENERAL ATOMIC

DATA ACQUISITION PROCESSING

C85

GENERAL ATOMIC COMPANY

GENERAL ATOMIC



HTGR CONTROL CONSOLE

PURPOSES OF THE DAP SYSTEM

1. PROVIDE OPERATORS WITH PLANT INFORMATION IN EASILY ASSIMILATED FORMAT.

C87

2. STORE PLANT DATA FOR OPTIONAL LATER USE IN ANALYSIS OF ABNORMAL EVENTS.

3. PROVIDE INFORMATION FOR PLANT SUPERVISION.

F-864(1)

GENERAL ATOMIC

DAP SYSTEM FUNCTIONS

- OPERATOR/COMPUTER COMMUNICATION.
- ANALOG POINT PROCESSING AND ALARM.
- DIGITAL POINT PROCESSING AND ALARM.
- ALARM SUPPRESSION.
- SEQUENCE OF EVENTS MONITORING.
- OPERATOR DEMAND FUNCTIONS.
- CATHODE RAY TUBE (CRT) INFORMATION DISPLAYS.
- ANALOG AND NUMERICAL TREND RECORDING.
- DATA LOGGING.
- POST TRIP REVIEW.
- DIAGNOSTICS AND SELF-CHECKING.
- NUCLEAR APPLICATIONS PROGRAMS.
- PERFORMANCE CALCULATIONS.
- OPERATOR GUIDES.
- EMERGENCY OPERATIONS FACILITIES SUPPORT.

F-864(2)

GENERAL ATOMIC

NUCLEAR APPLICATIONS PROGRAMS

CORE REACTIVITY STATUS

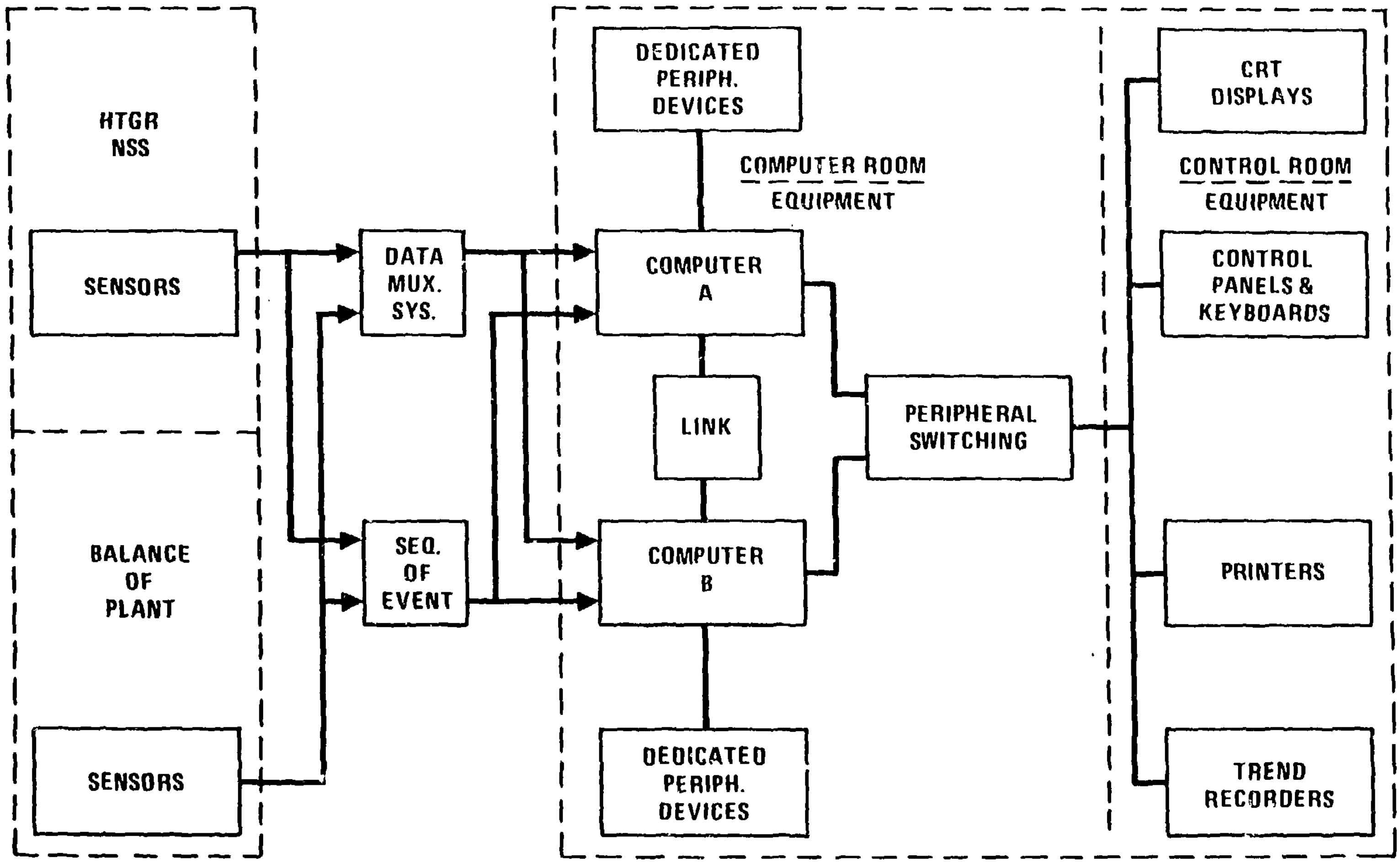
CORE POWER AND TEMPERATURE DISTRIBUTION

CORE HEAT BALANCE

ON-LINE CALIBRATION OF CONTROL RODS

DATA OUTPUT TO OFF-LINE CORE MANAGEMENT

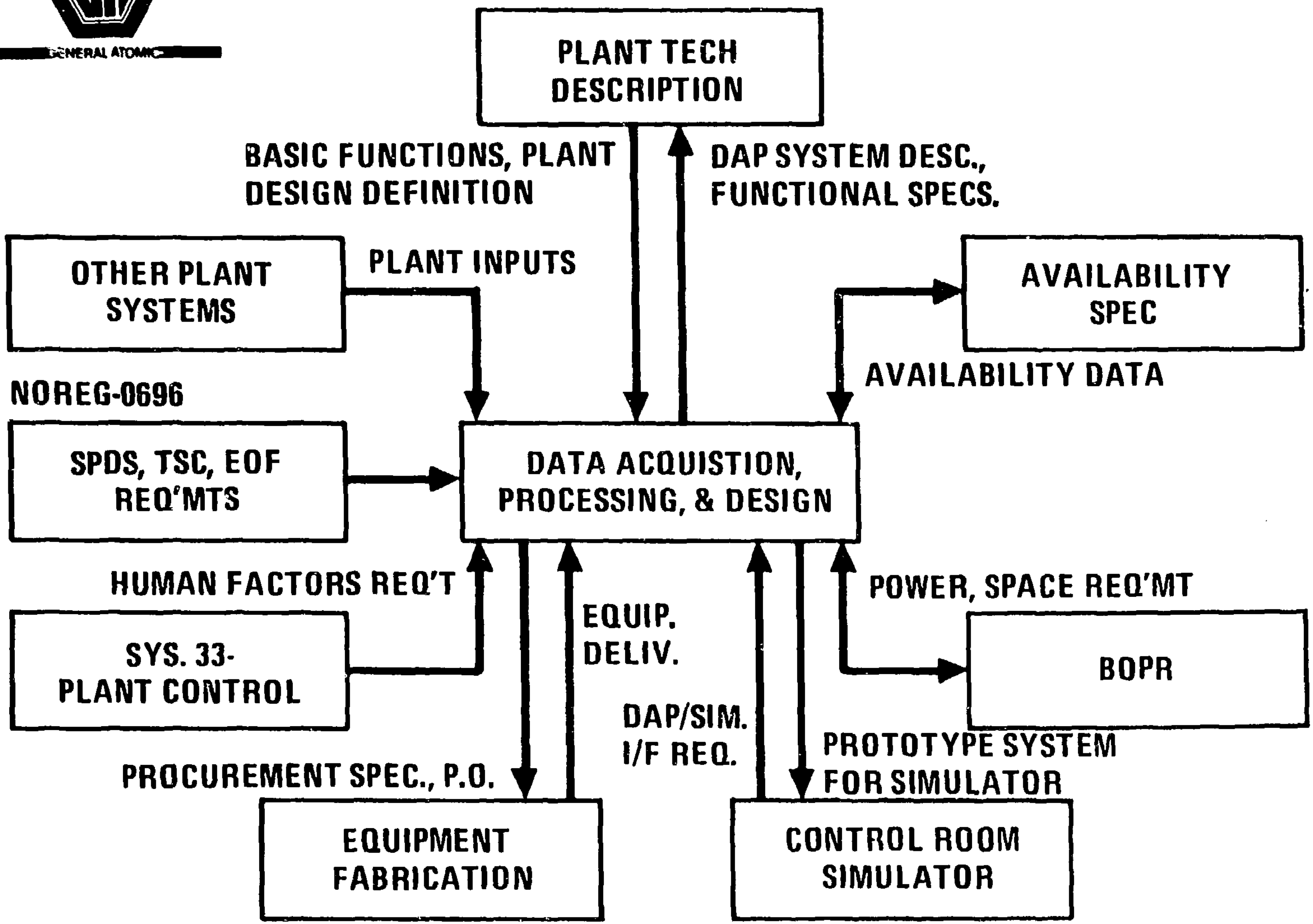
DAP SYSTEM ORGANIZATION



C63

F-864(3)

GENERAL ATOMIC

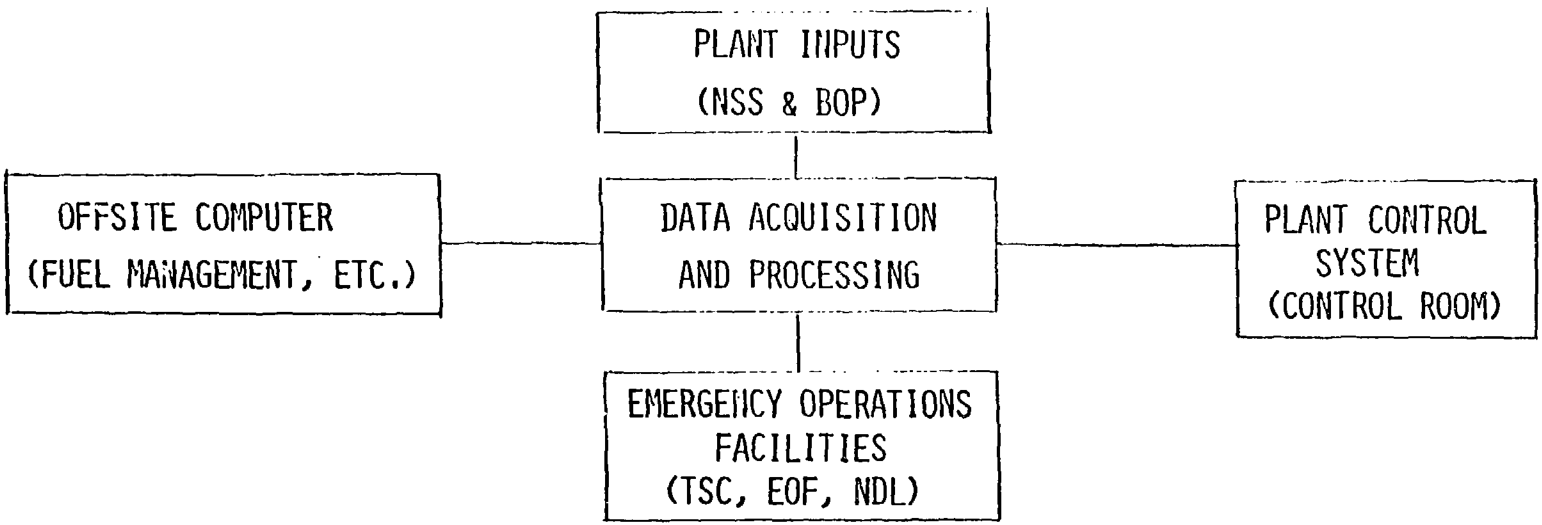


C91

F-888

DATA ACQUISITION AND PROCESSING

SYSTEM INTERFACE



GENERAL ATOMIC

DAP SYSTEM REQUIREMENT

A. SAFETY

1. SYSTEM IS NOT SAFETY CLASSIFIED BUT ACCEPTS INPUTS FROM SAFETY SYSTEMS THAT MUST BE PROPERLY ISOLATED.

2. SAFETY PARAMETER DISPLAY WILL BE DRIVEN FROM THE DAP SYSTEM. THIS WILL BE BACKED UP BY A SEPARATE SEISMICALLY HARDENED SPDS PROVIDED UNDER THE SAFETY-RELATED INSTRUMENTATION SYSTEM.

C93

B. FUNCTIONAL

1. HIGH AVAILABILITY BECAUSE OF PLANT OPERATIONS INFORMATION PROVIDED AND PLANT DIAGNOSTICS FEATURES.

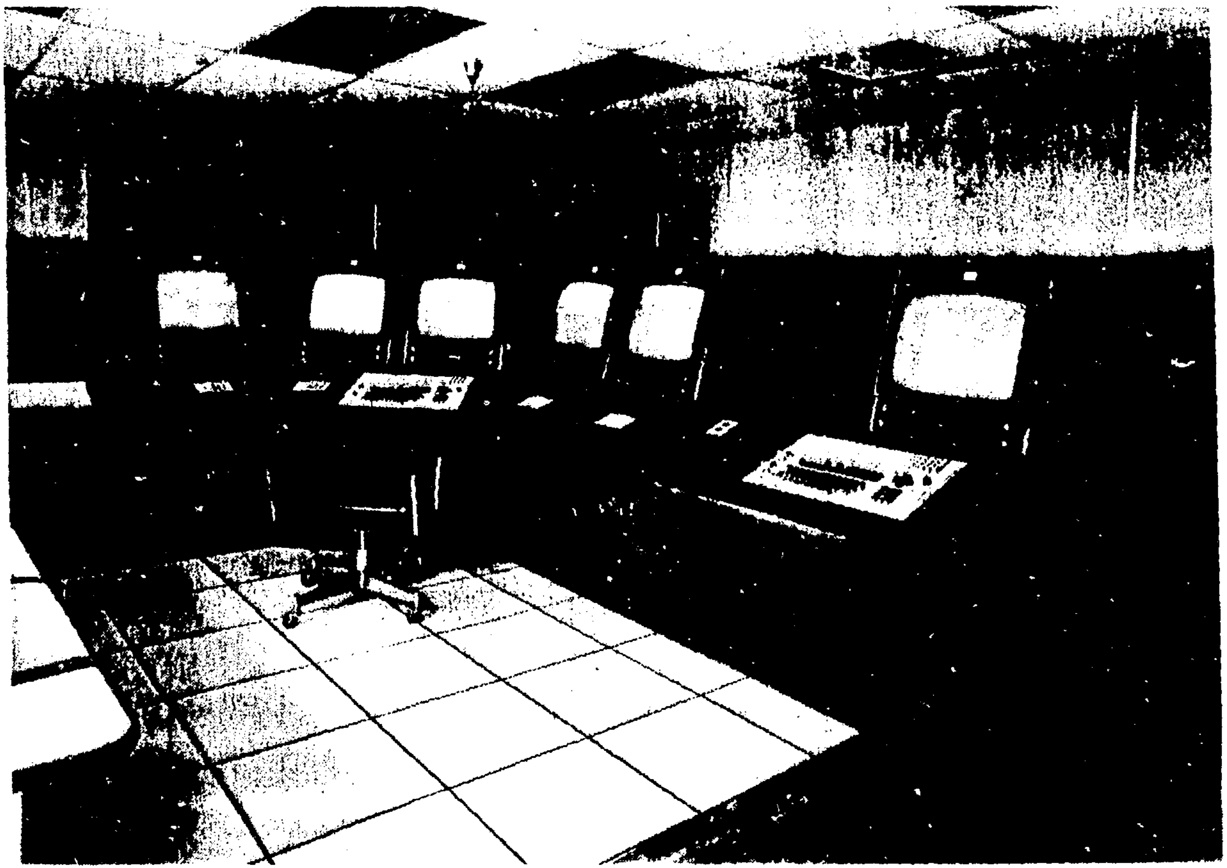
2. REMOTE MULTIPLEXING CAPABILITY FOR REDUCED COSTS AND IMPROVED INPUT INPUT SIGNAL QUALITY.

3. WELL ENGINEERING WITH RESPECT TO HUMAN FACTORS.

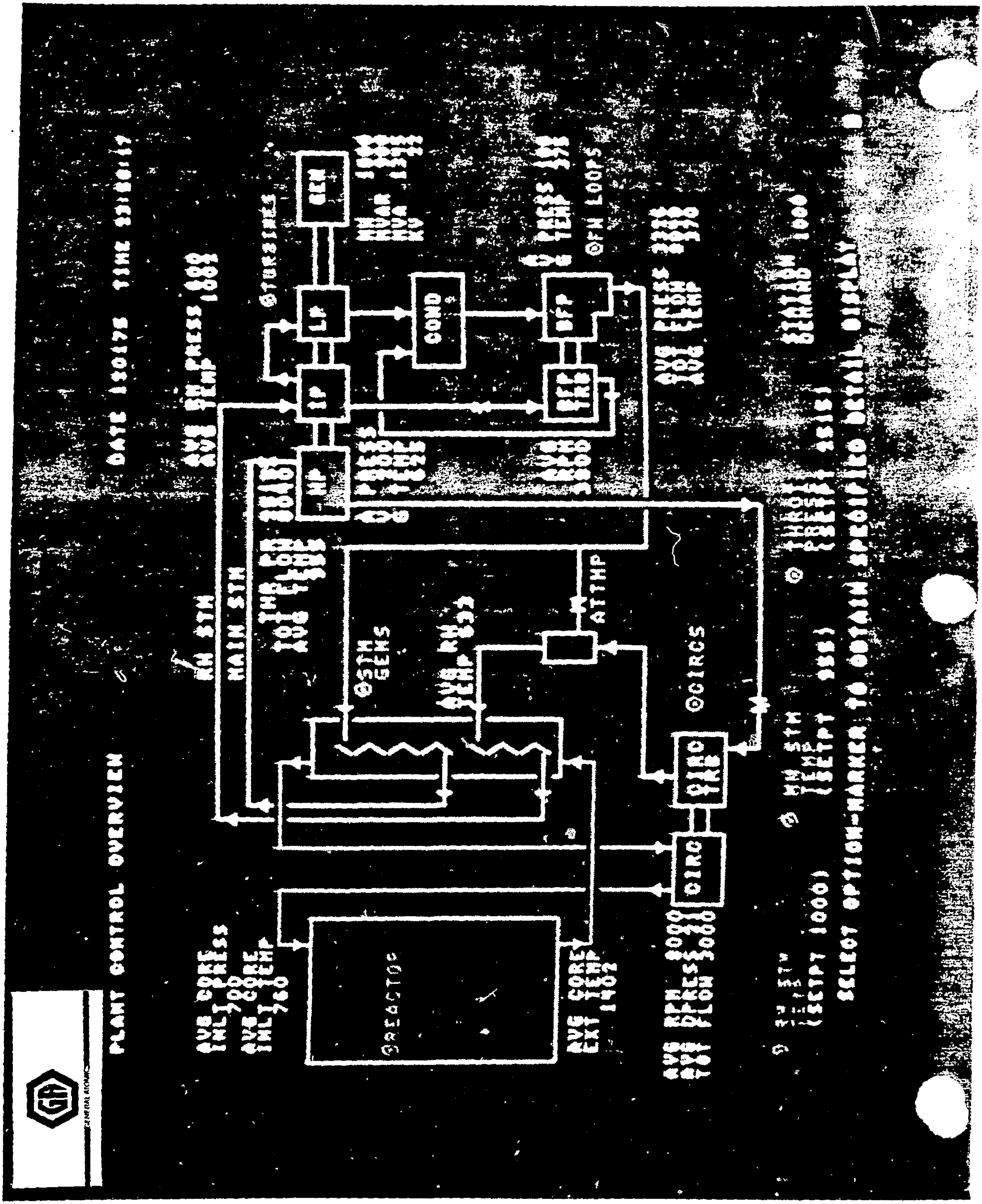
GENERAL ATOMIC

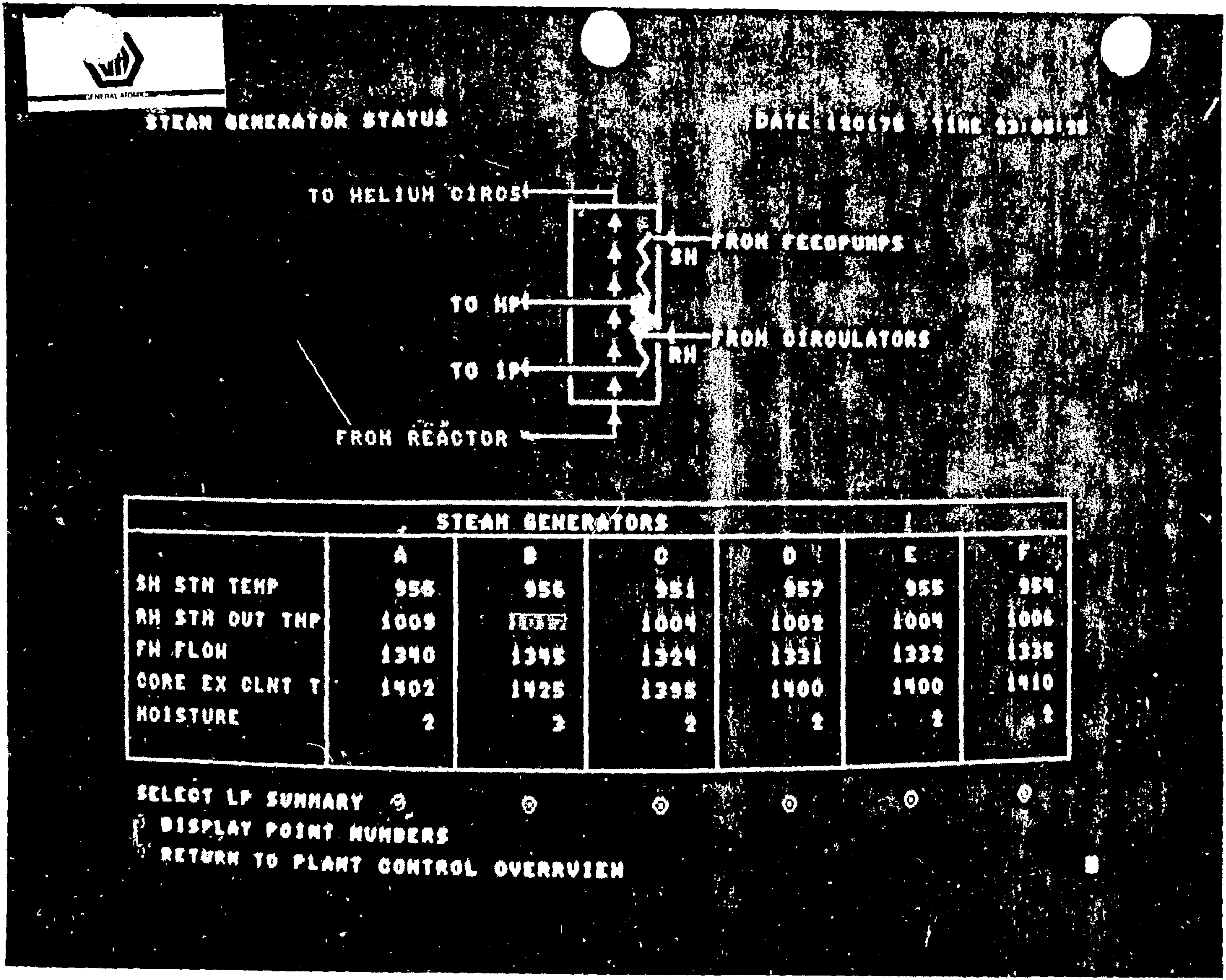
PROTOTYPE DAP SYSTEM DISPLAYS AND KEYBOARDS

C94

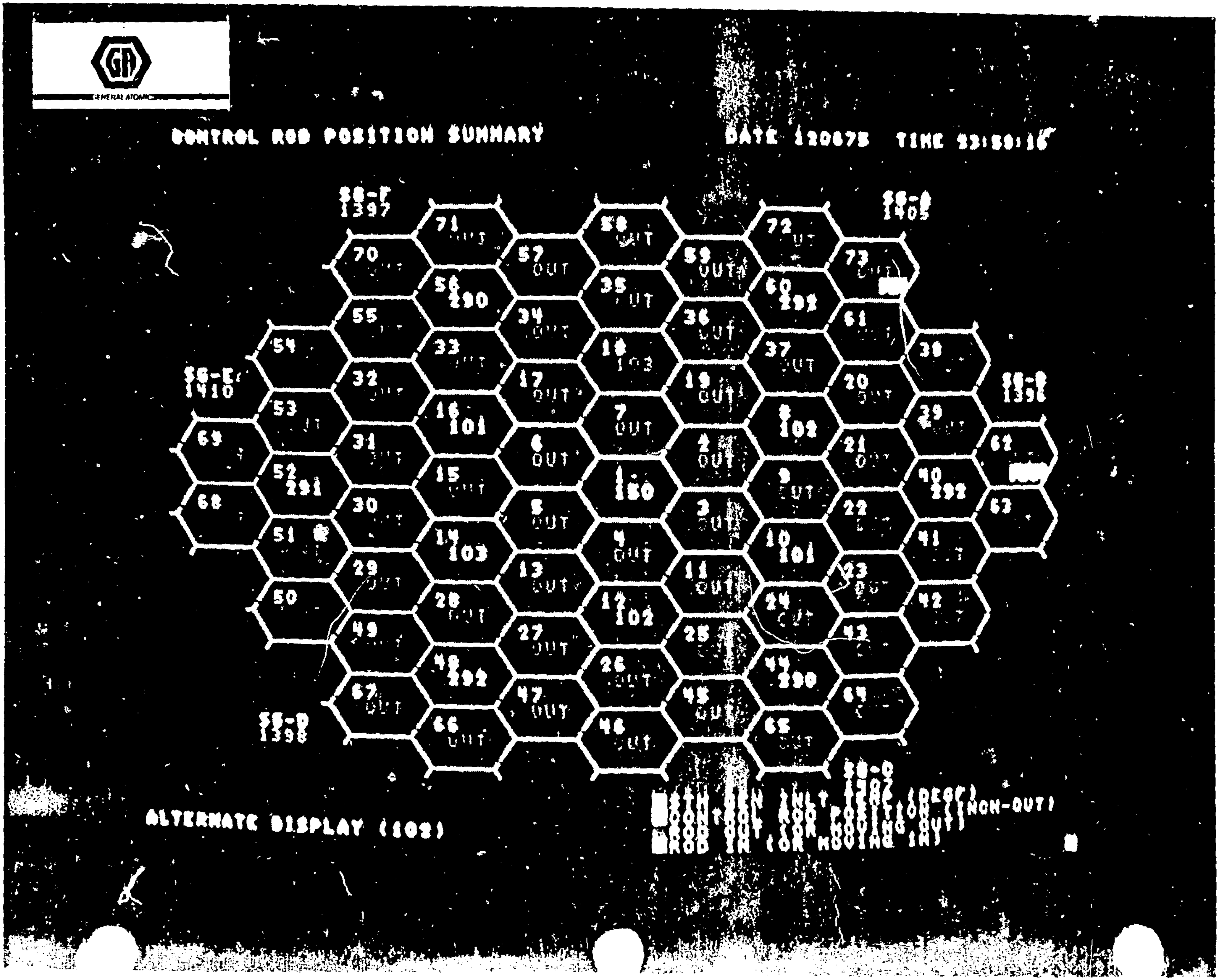


F-886


PLANT CONTROL OVERVIEW
RH STM
MAIN STM
REACTOR
AVG CORE INLT PRESS 700
AVG CORE INLT TEMP 760
AVG CORE EXT TEMP 1402
STM GENS
CIRC
CIRC TRB
CIRCS
ATTMP
HP
IP
LP
GEN
TURBINES
COND
BFP
FW LOOPS
SELECT OPTION-MARKER TO OBTAIN SPECIFIED DETAIL DISPLAY


GENERAL ATOMIC
STEAM GENERATOR STATUS
DATE
TIME
TO HELIUM CIRCS
FROM FEEDPUMPS
SH
TO HP
FROM CIRCULATORS
RH
TO IP
FROM REACTOR
STEAM GENERATORS
A B C D E F
SH STM TEMP 956 956 951 957 955 954
RH STM OUT TMP 1009 1004 1002 1004 1006
FW FLOW 1340 1345 1324 1331 1332 1335
CORE EX CLNT T 1402 1425 1395 1400 1400 1410
MOISTURE 2 3 2 2 2 2
SELECT LP SUMMARY
DISPLAY POINT NUMBERS
RETURN TO PLANT CONTROL OVERRVIEW

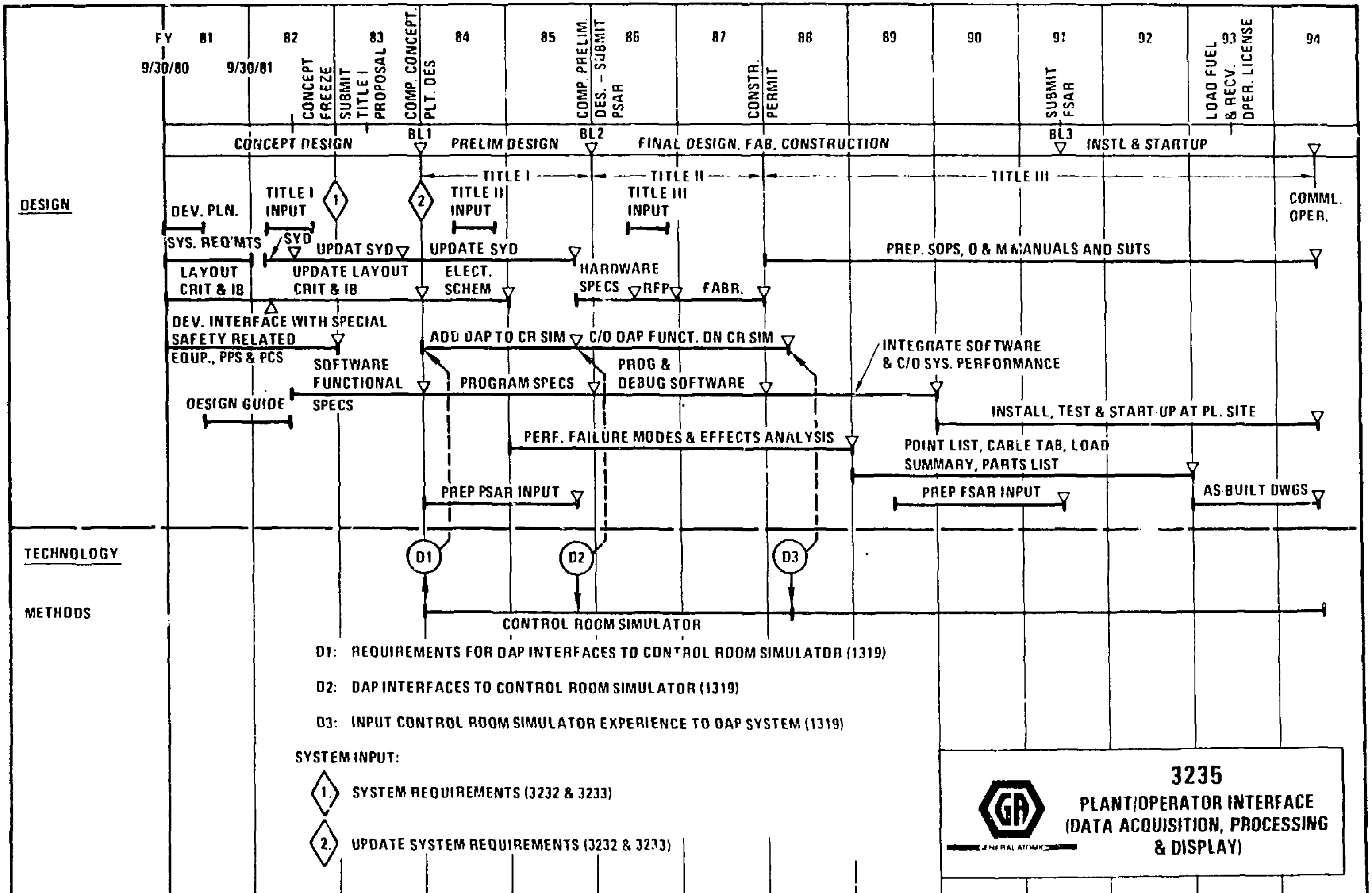
C96


GENERAL ATOMIC
CONTROL ROD POSITION SUMMARY
DATE 120875 TIME 23:50:16
SG-F 1397
SG-A 1405
SG-E 1410
SG-B 1396
SG-D 1398
SG-C
ALTERNATE DISPLAY (102)
ROD IN (OR MOVING IN)

EVOLUTION OF THE DAP SYSTEM FROM FSV PLANT COMPUTERS

GENERAL ATOMIC

1) DATA GATHERING AND DISPLAY IS CENTRALIZED INTO ONE SYSTEM RATHER THAN SPREAD OVER SEVERAL UNCORRELATED SYSTEMS.
2) REDUNDANCY OF COMPUTERS AND CRITICAL PERIPHERALS IS USED TO GREATLY IMPROVE SYSTEM AVAILABILITY.
3) MORE COLOR GRAPHIC DISPLAYS ARE USED TO IMPROVE THE PLANT OPERATOR'S ACCESS TO PLANT OPERATIONAL INFORMATION.
4) OPERATOR GUIDES ARE ADDED TO ASSIST THE PLANT OPERATOR IN EXECUTING VARIOUS PROCEDURES (E.G., START-UP, LOAD-CHANGE, NORMAL SHUT-DOWN, EMERGENCY SHUT-DOWN).
5) ADDITIONAL COMPUTATIONAL CAPABILITY IS PROVIDED TO IMPROVE QUALITY OF EXISTING FUNCTIONS AND TO PROVIDE FOR MORE EXPANDABILITY.
6) EMERGENCY RESPONSE FUNCTIONS (REF. NUREG-0696) ARE ADDED TO IMPROVE THE ABILITY TO OPERATE THE PLANT UNDER EMERGENCY CONDITIONS.


FY 81 82 83 84 85 86 87 88 89 90 91 92 93 94
9/30/80
9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. – SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV. OPER. LICENSE
CONCEPT DESIGN
BL1
PRELIM DESIGN
BL2
FINAL DESIGN, FAB, CONSTRUCTION
BL3
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
DESIGN
DEV. PLN.
TITLE I INPUT
TITLE II INPUT
TITLE III INPUT
COMML. OPER.
SYS. REQ'MTS
SYD
UPDAT SYD
UPDATE SYD
PREP. SOPS, O & M MANUALS AND SUTS
LAYOUT CRIT & IB
UPDATE LAYOUT CRIT & IB
ELECT. SCHEM
HARDWARE SPECS
RFP
FABR.
DEV. INTERFACE WITH SPECIAL SAFETY RELATED EQUP., PPS & PCS
ADD DAP TO CR SIM
C/O DAP FUNCT. ON CR SIM
INTEGRATE SOFTWARE & C/O SYS. PERFORMANCE
SOFTWARE FUNCTIONAL SPECS
PROGRAM SPECS
PROG & DEBUG SOFTWARE
DESIGN GUIDE
INSTALL, TEST & START-UP AT PL. SITE
PERF. FAILURE MODES & EFFECTS ANALYSIS
POINT LIST, CABLE TAB, LOAD SUMMARY, PARTS LIST
PREP PSAR INPUT
PREP FSAR INPUT
AS-BUILT DWGS
TECHNOLOGY
METHODS
D1
D2
D3
CONTROL ROOM SIMULATOR
D1: REQUIREMENTS FOR DAP INTERFACES TO CONTROL ROOM SIMULATOR (1319)
D2: DAP INTERFACES TO CONTROL ROOM SIMULATOR (1319)
D3: INPUT CONTROL ROOM SIMULATOR EXPERIENCE TO DAP SYSTEM (1319)
SYSTEM INPUT:
1. SYSTEM REQUIREMENTS (3232 & 3233)
2. UPDATE SYSTEM REQUIREMENTS (3232 & 3233)
GENERAL ATOMIC
3235
PLANT/OPERATOR INTERFACE (DATA ACQUISITION, PROCESSING & DISPLAY)

F-859(13)

GENERAL ATOMIC

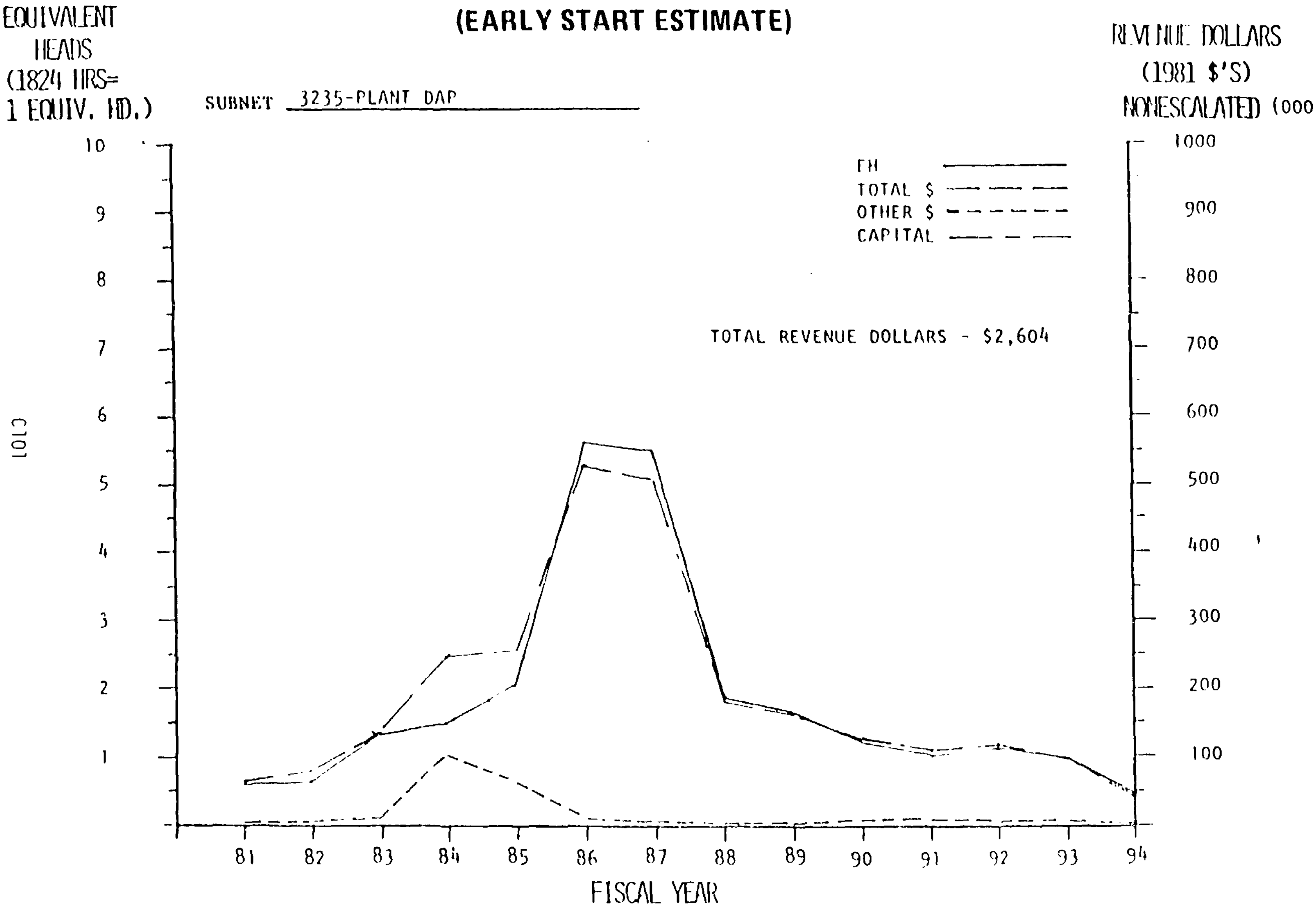
DESIGN DATA NEEDS

DDN NO.	TITLE	PRIORITY	FACILITIES	COST
2.35.C.1	REQUIREMENTS FOR SAFETY PARAMETER DISPLAYS	T2	NONE	NONE
2.35.C.2	HUMAN FACTORS REQUIREMENTS	T2	*	114
2.35.C.3	REQUIREMENTS FOR SAFETY-RELATED DAP SYSTEM FUNCTIONS	T2	NONE	NONE

* CONTROL ROOM SIMULATOR – SAME FACILITY AS THAT USED FOR PLANT CONTROL SYSTEM

C100

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)



DAP SYSTEM EQUIPMENT PRICE

GENERAL ATOMIC

PRICE TO UTILITY IN $1000's

COMPUTERS AND MAIN MEMORY	490
PERIPHERAL EQUIPMENT	736
PLANT INPUT MULTIPLEXING EQUIPMENT	1226
TOTAL	2452

F-891(2)

C102

C103

ANALYTICAL INSTRUMENTATION

GENERAL ATOMIC COMPANY

ANALYTICAL INSTRUMENTATION

FUNCTIONAL REQUIREMENTS

C104

- PROVIDE SURVEILLANCE DATA TO VERIFY CONFORMANCE TO TECHNICAL SPECIFICATIONS (LIMITS ON GRAPHITE OXIDANTS AND PRIMARY COOLANT IMPURITIES)
- PROVIDE ANALYSIS OF NSS SYSTEM RADIOACTIVE DISCHARGES TO THE ENVIRONS

GENERAL ATOMIC

ANALYTICAL INSTRUMENTATION

MAJOR COMPONENTS

C105

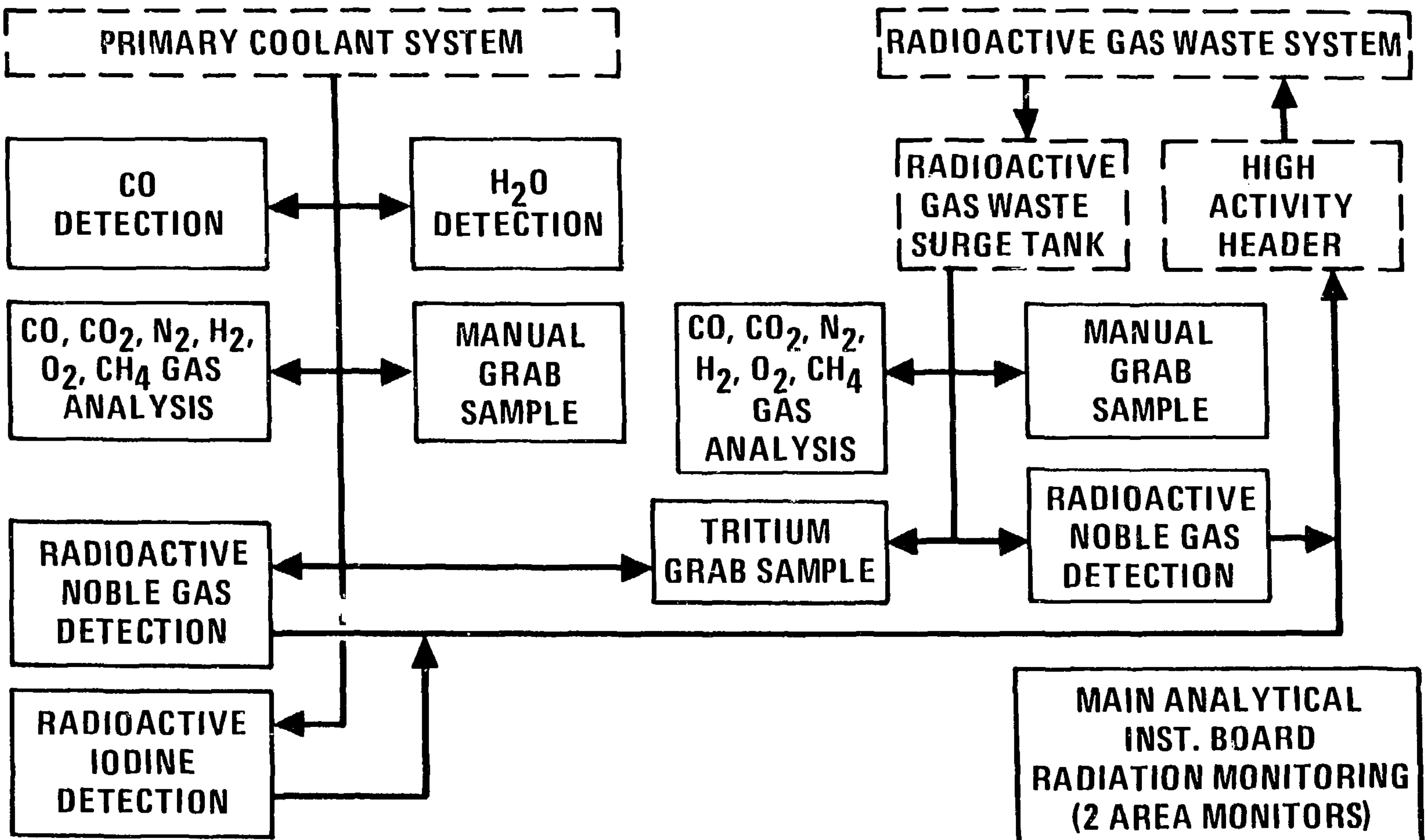
- PRIMARY COOLANT SAMPLE DEPRESSURIZATION RACK
- MOISTURE MONITOR
- TRITIUM MONITOR
- GAS CHROMATOGRAPH
- CO ANALYZER
- RADIOACTIVE NOBLE GAS MONITOR
- RADIOACTIVE IODINE MONITOR
- GRAB SAMPLE RACK

F-865(2)

ANALYTICAL INSTRUMENTATION FUNCTIONAL DIAGRAM

GENERAL ATOMIC

PART I

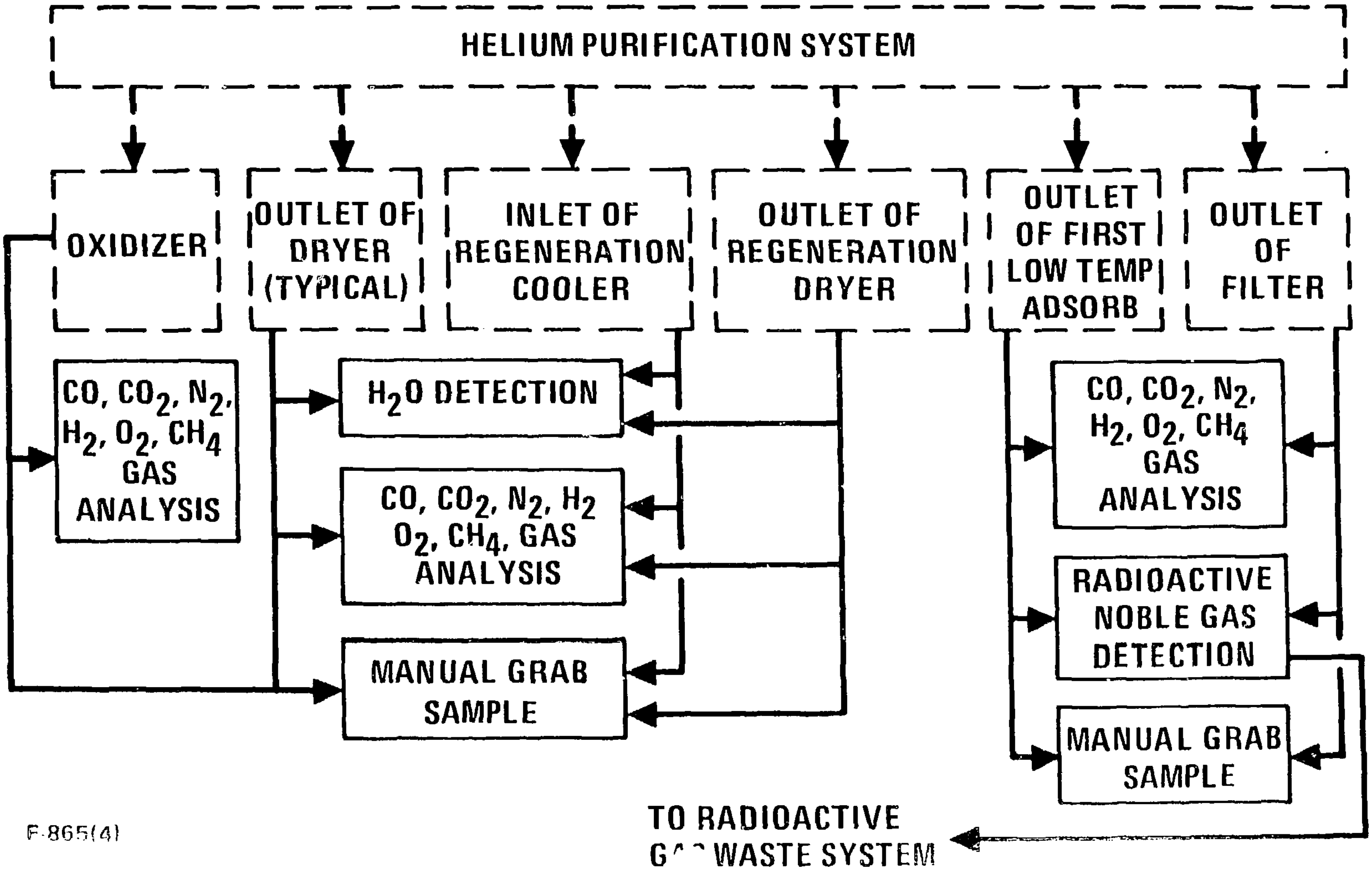


F-865(3)

C106

ANALYTICAL INSTRUMENTATION FUNCTIONAL DIAGRAM

PART II



C107

F-865(4)

ANALYTICAL INSTRUMENTATION

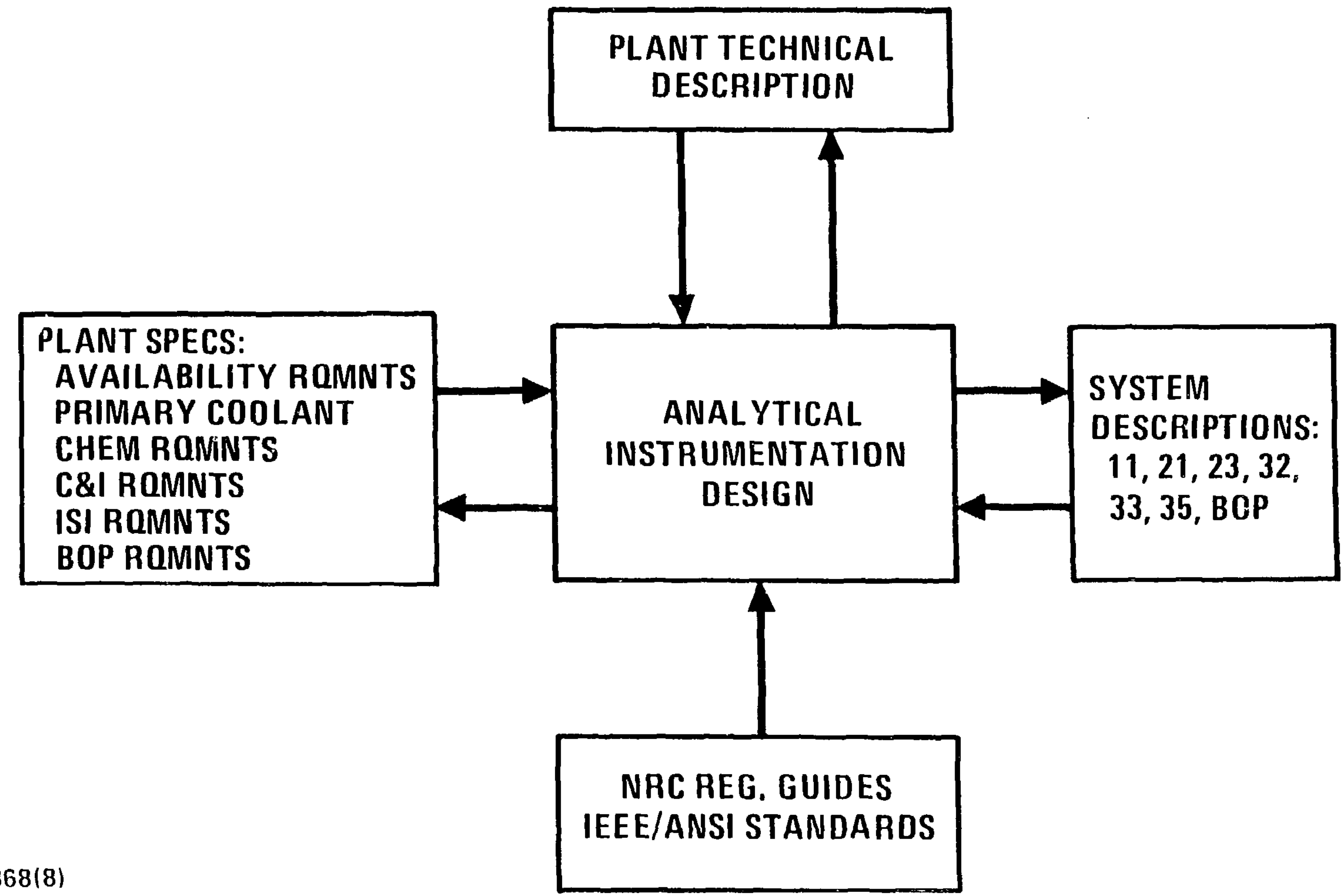
EVOLUTION FROM FSV DESIGN

C108

- INCREASE MOISTURE MONITOR ACCURACY AND RANGE FOR LOW LEVELS (<10 PPMV) OF MOISTURE
- USE IMPROVED GAS CHROMATOGRAPH TECHNOLOGY WITH AUTOMATIC INJECTION AND PURGE CAPABILITY
- MEASURE IODINE SPECIES IN HIGH TEMPERATURE PORTION OF THE PRIMARY COOLANT

ANALYTICAL INSTRUMENTATION

DESIGN REQUIREMENTS



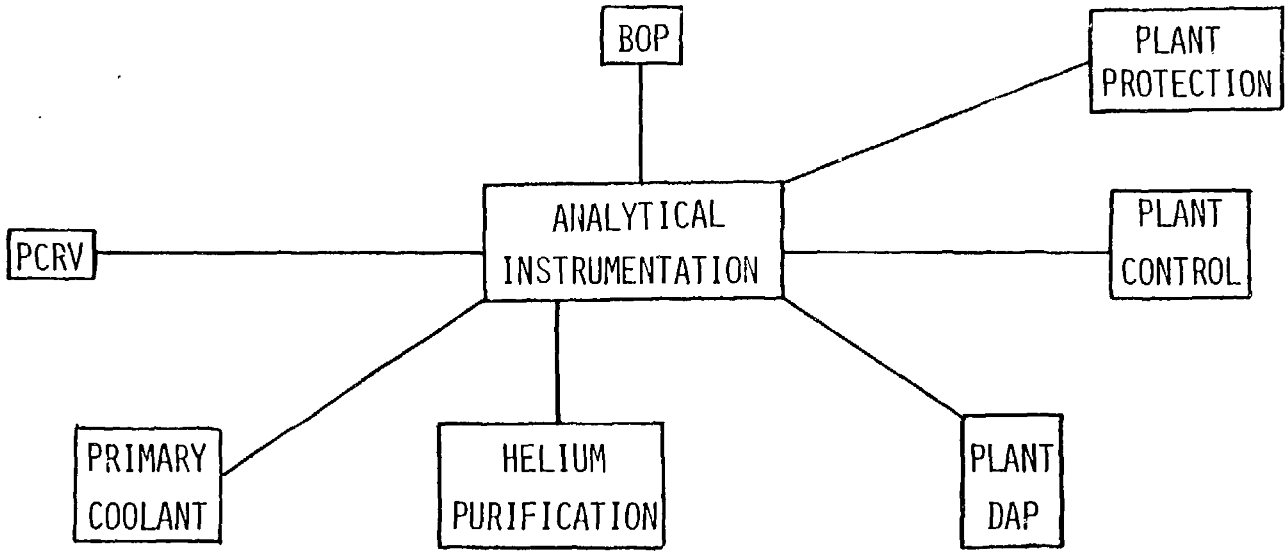
C109

F-868(8)

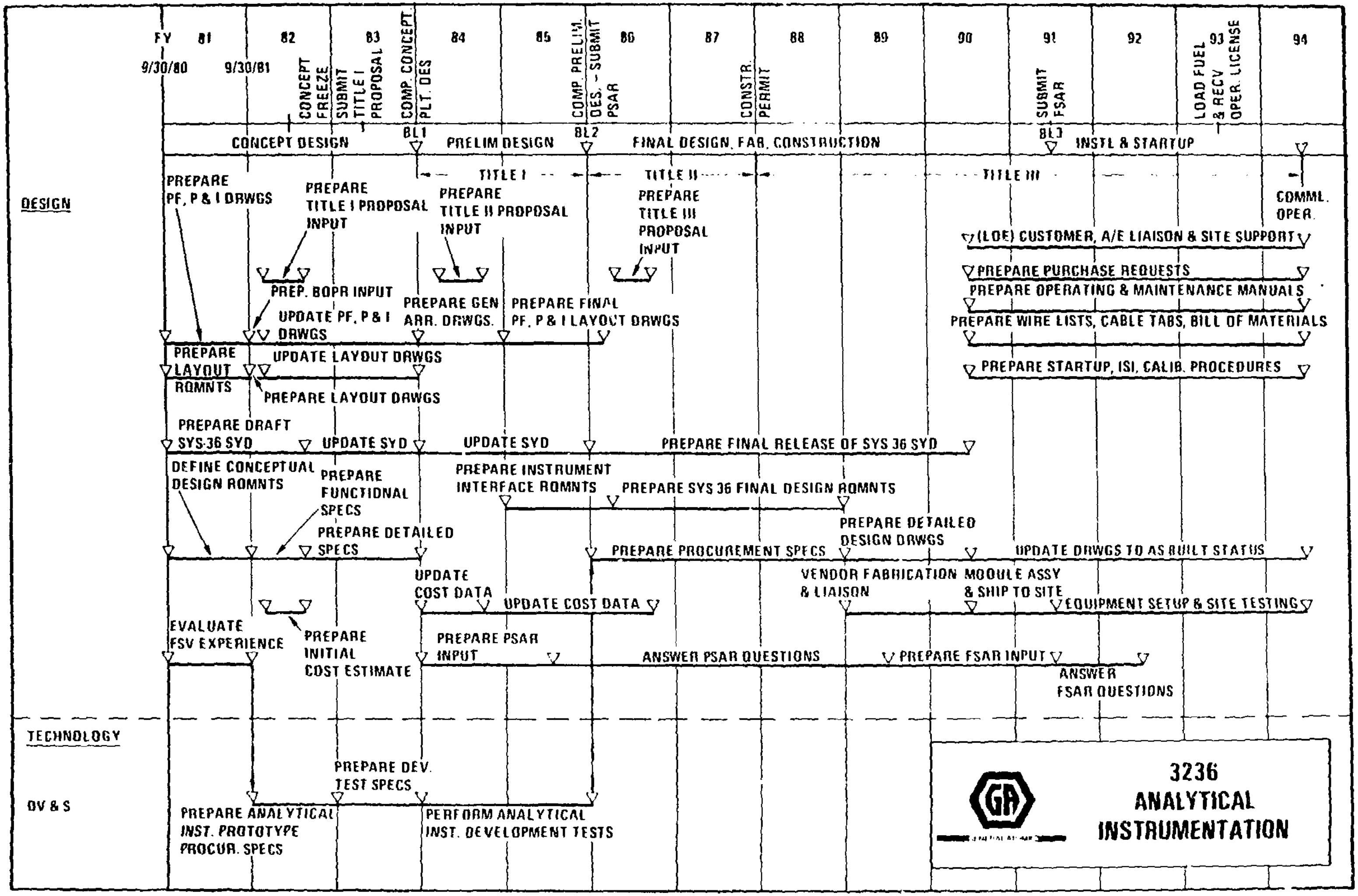
GENERAL ATOMIC

ANALYTICAL INSTRUMENTATION

SYSTEM INTERFACES



C110


FY 81 82 83 84 85 86 87 88 89 90 91 92 93 94
9/30/80
9/30/81
CONCEPT FREEZE
SUBMIT TITLE I PROPOSAL
COMP. CONCEPT. PLT. DES
COMP. PRELIM. DES. - SUBMIT PSAR
CONSTR. PERMIT
SUBMIT FSAR
LOAD FUEL & RECV OPER. LICENSE
BL1
BL2
BL3
CONCEPT DESIGN
PRELIM DESIGN
FINAL DESIGN, FAB, CONSTRUCTION
INSTL & STARTUP
TITLE I
TITLE II
TITLE III
COMML. OPER.
DESIGN
PREPARE PF, P & I DRWGS
PREPARE TITLE I PROPOSAL INPUT
PREPARE TITLE II PROPOSAL INPUT
PREPARE TITLE III PROPOSAL INPUT
(LOE) CUSTOMER, A/E LIAISON & SITE SUPPORT
PREPARE PURCHASE REQUESTS
PREPARE OPERATING & MAINTENANCE MANUALS
PREPARE WIRE LISTS, CABLE TABS, BILL OF MATERIALS
PREP. BOPR INPUT
UPDATE PF, P & I DRWGS
PREPARE GEN ARR. DRWGS.
PREPARE FINAL PF, P & I LAYOUT DRWGS
PREPARE LAYOUT RQMNTS
UPDATE LAYOUT DRWGS
PREPARE LAYOUT DRWGS
PREPARE STARTUP, ISI, CALIB. PROCEDURES
PREPARE DRAFT SYS-36 SYD
UPDATE SYD
UPDATE SYD
PREPARE FINAL RELEASE OF SYS 36 SYD
DEFINE CONCEPTUAL DESIGN RQMNTS
PREPARE FUNCTIONAL SPECS
PREPARE INSTRUMENT INTERFACE RQMNTS
PREPARE SYS 36 FINAL DESIGN RQMNTS
PREPARE DETAILED SPECS
PREPARE PROCUREMENT SPECS
PREPARE DETAILED DESIGN DRWGS
UPDATE DRWGS TO AS BUILT STATUS
UPDATE COST DATA
UPDATE COST DATA
VENDOR FABRICATION & LIAISON
MODULE ASSY & SHIP TO SITE
EQUIPMENT SETUP & SITE TESTING
EVALUATE FSV EXPERIENCE
PREPARE INITIAL COST ESTIMATE
PREPARE PSAR INPUT
ANSWER PSAR QUESTIONS
PREPARE FSAR INPUT
ANSWER FSAR QUESTIONS
TECHNOLOGY
DV & S
PREPARE DEV. TEST SPECS
PREPARE ANALYTICAL INST. PROTOTYPE PROCUR. SPECS
PERFORM ANALYTICAL INST. DEVELOPMENT TESTS
GA
3236
ANALYTICAL INSTRUMENTATION

F 859(14)

(111)

ANALYTICAL INSTRUMENTATION

SYSTEM – 36

DESIGN DATA NEEDS

DDN #	TITLE	PRIORITY	FACILITIES	COST ($K)
2.36.1	VERIFY ADEQUATE REPEATABILITY AND RELIABILITY OF THE GAS ANALYZING SYSTEM BY PERFORMING PROTOTYPE DESIGN VERIFICATION TESTING OF THE NOBLE GAS SAMPLER, MOISTURE MONITOR, TRITIUM MONITOR, CO ANALYZER, IODINE MONITOR, AND GAS CHROMATOGRAPH.	(T2)	EXISTING GA LABS	353

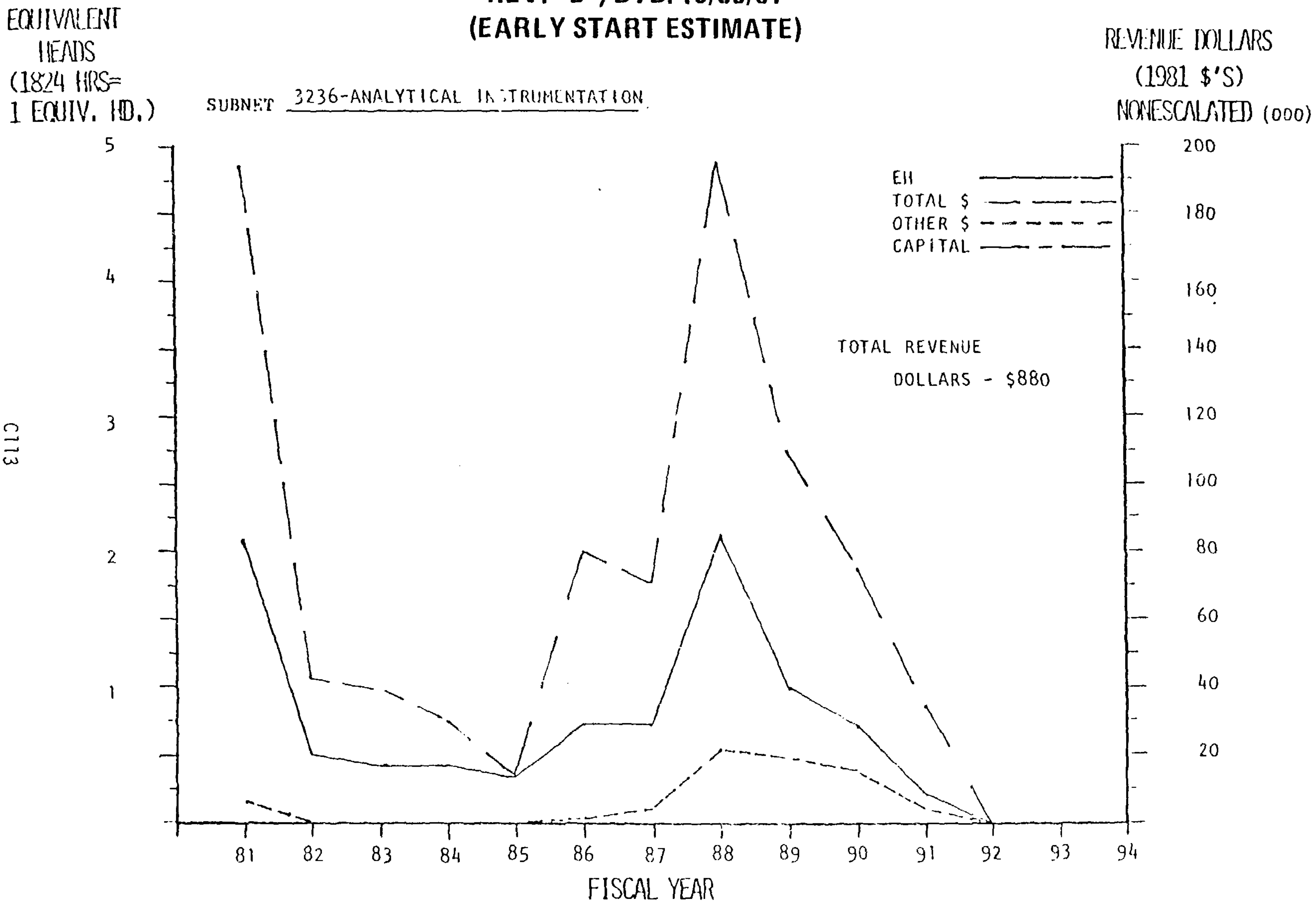
F-865(6)

C112

GENERAL ATOMIC

HTGR-SC/C DESIGN PROJ. NO. 6654
REV. "B", DTD. 10/30/81
(EARLY START ESTIMATE)

SUBNET 3236-ANALYTICAL INSTRUMENTATION



C113

NOTE OPTIMIZED/LF LOADED

GENERAL ATOMIC

ANALYTICAL INSTRUMENTATION

SYSTEM PRICE

$500 K

C174

F-896(2)

PART D

WORKING SESSION

PRESENTERS:

D. P. Giegler (GA)
D. Kapich (GA)
J. M. Krase (GA)
M. K. Nichols (GA)
C. Rodriguez (GA)
J. Vavrina (GA)

PART D

WORKING SESSION

The working session was to obtain the GA response to the written questions that had been submitted by the review team and other questions which had been deferred from previous sessions. Since the bulk of these fall into the written category, all questions and answers are reported on the comment/question and response forms that follow. The attendance list for this part of the meeting is also attached.

Attendance
Scession II C
12/10/81

Name	Organization
Fred Swart	GCRA
CURT FORKEL	EG&G
JAMES ZGLICZYNSKI	GA
Hank Fong	GA
W. H. ROACH	EG&G
L. M. WELSHANS	DOE
K. R. VAN HOWE	SMSC
Robert F. Stearns	Bechtel
John M. Gurley	Gen. Elec. ARSD
O.R. BOLAND	GA.
PAUL KASTEN	ORNL
CLIVE DUPEN	C-E
Vincent G. Scotti	CE
R. A. Evans	GCRA

COMMENTS/QUESTIONS AND RESPONSE

NO. 1

SESSION IIC (Deferred from IIA) ORG EG&G

ITEM Core Auxiliary Cooling System REVIEWER M. L. Griebenow

REVIEW ITEM Technology Development Plan

COMMENT/QUESTION

We could find no hybrid, CACS model development or updating in the tasks costed yet the design plan includes simulator evaluation of CACS operating procedures.

RESPONSE

This was erroneously included with the design for the CACS. It should have been listed with the DV&S Technology Program. This will be corrected by transferring 160 man hours from design to DV&S Technology Program.

COMMENTS/QUESTIONS AND RESPONSE

NO. 2

SESSION IIC

ORG SMSC

ITEM Auxilliary Circulator

REVIEWER K. R. Van Howe

REVIEW ITEM Reverse Windmilling Speed

COMMENT/QUESTION

What is the speed of the circulator windmilling in reverse with the ALIV open?

RESPONSE

This will be determined in the 1/3 scale test. The specification requires a tachometer to indicate the speed to the operator. There is no automatic device and no manual directive to the operator to take any action in regard to the motor spinning in the opposite direction. There is not a great deal of concern about the motor spinning in the reverse direction. Rotation is desired in some direction to keep the bearings from brinelling. If the 1/3 scale tests show the life of the bearings is threatened, the spin will be limited in some manner.

COMMENTS/QUESTIONS AND RESPONSE

NO. 3

SESSION IIC

ORG SMSC

ITEM Safety Related Instrumentation

REVIEWER K. R. Van Howe

REVIEW ITEM Collection Rake Location

COMMENT/QUESTION

Detection of moisture at the bottom of the steam generator (steam generator outlet) possibly in conjunction with a circulator outlet will allow definitive indication of steam generator vs. circulator water ingress. This sample point will also allow definitive moisture detection of a steam generator tube leak for a shutdown steam generator and will eliminate any requirement for draining a shutdown steam generator. GA should consider other points for moisture collection rakes.

RESPONSE

GA will consider other points for the location of moisture collection rakes. GA has not considered this in the past. However, it is pointed out that after the helium has made several trips around the loop, the location of the leak may not be distinguishable.

COMMENTS/QUESTIONS AND RESPONSE

NO. 4

SESSION IIC | ORG Bechtel

ITEM Reactor Service Equipment | REVIEWER R. F. Stearns

REVIEW ITEM Containment Isolation System

COMMENT/QUESTION

I don't see why the containment should isolate due to high radiation existing in the Reactor Service Building (RSB).

I can see isolation of a specific line leaving the reactor containment, such as the helium purification line. High radiation in the RSB could come from something like moving a "hot" object near the radiation monitor.

Review this requirement carefully so as not to have any unnecessary RCB containment isolation/reactor trip.

RESPONSE

This is a good question. Obviously, the reactor should not be tripped as a result of a source being moved in the RSB. This is indicated on the drawings as a BOP imposed requirement, but the real requirement may be to only isolate the RSB from the containment building as Mr. Stearns indicates. GA will take this up with the architect engineer.

COMMENTS/QUESTIONS AND RESPONSE

NO. 5

SESSION IIC

ORG SMSC

ITEM Safety Related Instrumentation

REVIEWER K. R. Van Howe

REVIEW ITEM PPS Monitoring System Design Adequacy

COMMENT/QUESTION

Clear basis for the radioactivity barrier protection requirements of the various PPS trips have not been defined. It appears that some of these may be directed toward equipment protection and not public health and safety. The NRC is beginning to emphasize that PPS trips be on actual parameters which are important to safety and not anticipatory parameters. Need clear and precise definition of PPS trips and why they are important to safety.

RESPONSE

GA objects that the basis for PPS trips has been defined, but perhaps not as well as they could be. As the design now exists, the walls of the steam generator are a part of the primary coolant boundary. Isolating the loop is not adequate protection. As presently defined, the containment boundary ends with the isolation valve on the steam generator pipe leaving the PCRV. The tube in the steam generator is a part of the primary coolant boundary and therefore must be protected by temperature sensors. The NRC has not required diversity but it has encouraged diversity. GA agrees to an action item to address the question of separating from the PPS those functions that protect in-plant equipment but not the public in the preparation of the system description for the SC/C plant which is scheduled to be issued in May 1982.

COMMENTS/QUESTIONS AND RESPONSE

NO. 6

SESSION IIC

ORG SMSC

ITEM Safety Related Instrumentation

REVIEWER K. R. Van Howe

REVIEW ITEM Cost Peak Late in Design of Moisture Monitor

COMMENT/QUESTION

Why does the cost chart titled "HTGR-SC/C Design Project No. 6654 Rev. B, Dated 10/30/81 - Subnet 3232 - Safety Related C&I System, Band Moisture Monitor" have the large peak at 1988 to 1992?

RESPONSE

The costs are for the qualification of the equipment as Class 1E. This is also included under DV&S in the PPS qualification effort. This cost of $550 k will be deleted from this chart because it does not belong in the design effort.

COMMENTS/QUESTIONS AND RESPONSE

NO. 7

SESSION IIC (Deferred from IIA) ORG GE-ARSD

ITEM Safety Related Instrumentation REVIEWER J. Impellezzeri

REVIEW ITEM Automatic Initiation of the CACS

COMMENT/QUESTION

What reactor plant conditions/sensor signal levels initiate an automatic CACS startup? Could minor plant transients (i.e., interruption of power, temporary trip of feedwater pumps, etc.) put the reactor plant in an emergency mode by automatically initiating the CACS and isolating the primary loops? Evaluate PPS conditions/signal levels/effects that initiate CACS startup to insure a false initiation is minimized.

RESPONSE

CACS automatic initiation occurs on:

Low plant feedwater flow rate at	∿10% plant flow*
Low plant helium flow rate at	∿11% plant flow*
High containment pressure	∿20 psia*

Minor plant transients do not automatically initiate CACS. The limiting safety system settings are chosen far enough below power operation flow levels and far enough above power operation pressure level to preclude initiation by minor transients.

*preliminary values

COMMENTS/QUESTIONS AND RESPONSE

NO. 8

SESSION IIC | ORG SMSC

ITEM Safety Related Instrumentation | REVIEWER K. R. Van Howe

REVIEW ITEM Reactor Trip Settings

COMMENT/QUESTION

What is the basis for reactor trip settings, PPS parameters? Also, loop shutdown and CACS actuation. Example: High temperature actuates main loop shutdown. Why?

What are the limiting safety system settings?

RESPONSE

The question is answered generically by the following supplementary handout for safety related instrumentation.

CALCULATIONS FOR BASES FOR HTGR SC/C PPS SETTINGS			
EQUIP. NO.	PROJ. NO.	CALC. NO.	PAGE 1 OF 2
PREPARED BY DPG	DATE 12/8/81	REF. DOCUMENTS:	
REVIEWED BY	DATE		
APPROVED BY	DATE		

THE BASES FOR HTGR SC/C PLANT PROTECTION SYSTEM SETTINGS ARE LIMITING SAFETY SYSTEM SETTINGS AS DEFINED BY 10 CFR 50, ¶ 50.36:

(1) *Safety limits, limiting safety system settings, and limiting control settings.* (i)(A) Safety limits for nuclear reactors are limits upon important process variables which are found to be necessary to reasonably protect the integrity of certain of the physical barriers which guard against the uncontrolled release of radioactivity. If any safety limit is exceeded, the reactor shall be shut down. The licensee shall notify the Commission, review the matter and record the results of the review, including the cause of the condition and the basis for corrective action taken to preclude reoccurrence. Operation shall not be resumed until authorized by the Commission.

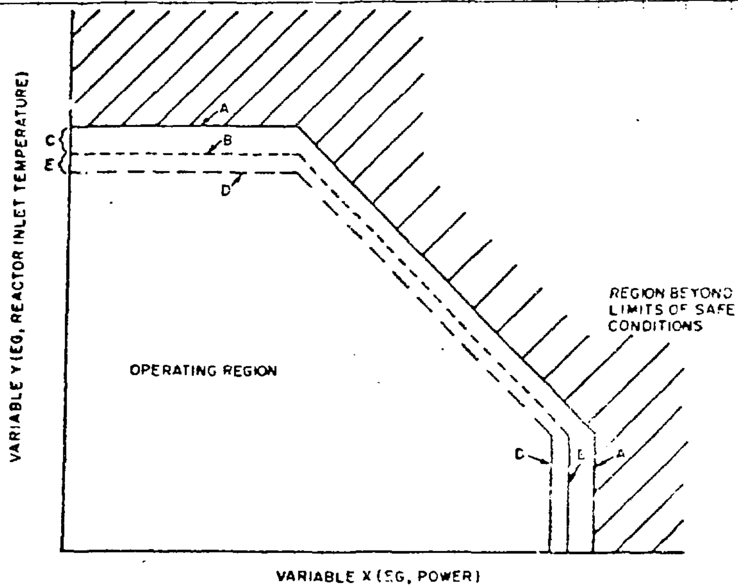
(ii)(A) Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting shall be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded. If, during operation, the automatic safety system does not function as required, the licensee shall take appropriate action, which may include shutting down the reactor. He shall notify the Commission, review the matter and record the results of the review, including the cause of the condition and the basis for corrective action taken to preclude reoccurrence.

SAFETY LIMITS FOR HTGR SC/C ARE GIVEN IN APPENDIX B OF "NUCLEAR SAFETY PLANT SPECIFICATION - HTGR SC/C, 2240 MW(t)" THE REACTOR SAFETY LIMITS PROVIDED IN APPENDIX B ARE SUPPLIED AS PART OF COMPONENT DESIGN.

GIVEN A SAFETY LIMIT, THE SAFETY SYSTEM DESIGN BASIS OF IEEE STD 603-1980 IS USED TO DETERMINE HTGR SC/C PPS SETTINGS. FIGURE 6 EXTRACTED FROM THE STANDARD ILLUSTRATES THE FACTORS CONSIDERED IN ARRIVING AT PPS SETTINGS.

GENERAL ATOMIC COMPANY

CALCULATIONS FOR			
EQUIP. NO.	PROJ. NO.	CALC. NO.	PAGE 2 OF 2
PREPARED BY	DATE	REF. DOCUMENTS:	
REVIEWED BY	DATE		
APPROVED BY	DATE		



A Safety Limit — Represents limits of safe conditions

B Setpoint Allowable Value — Represents the least *restrictive setpoints which may exist at any time*

C Allowance for calibration errors, instrument accuracy, and transient overshoot (this allowance may be a function of variable X or variable Y or both)

D Trip Setpoint — Nominal setpoints set to ensure that drift will not result in setpoints exceeding the setpoint allowable value of B

E Allowance for instrument and setpoint drift (this allowance may be a function of variable X or variable Y or both)

Fig 6
Example of Relationship Between Nominal Safety System Setpoints and Limits of Safe Conditions

COMMENTS/QUESTIONS AND RESPONSE

NO. 9

SESSION IIC

ORG SMSC

ITEM Moisture Monitor System

REVIEWER K. R. Van Howe

REVIEW ITEM Prevention of Condensation in Sample Line

COMMENT/QUESTION

The moisture monitor at FSV had condensation in the sample lines. How is this to be prevented in the HTGR-SC/C plant?

RESPONSE

Condensation in the sample lines will be prevented by heat tracing the pipes. This will extend all the way through the PCRV walls.

COMMENTS/QUESTIONS AND RESPONSE

NO. 10

SESSION IIC

ORG SMSC

ITEM Plant Protection System

REVIEWER K. R. Van Howe

REVIEW ITEM Replacement of Helium Temperature Sensors

COMMENT/QUESTION

Can the helium temperature sensors that actuate the PPS be replaced?

RESPONSE

Yes. See the following pages from the supplemental handout for the safety related insturmentation system.

GA 268 REV. 6-79

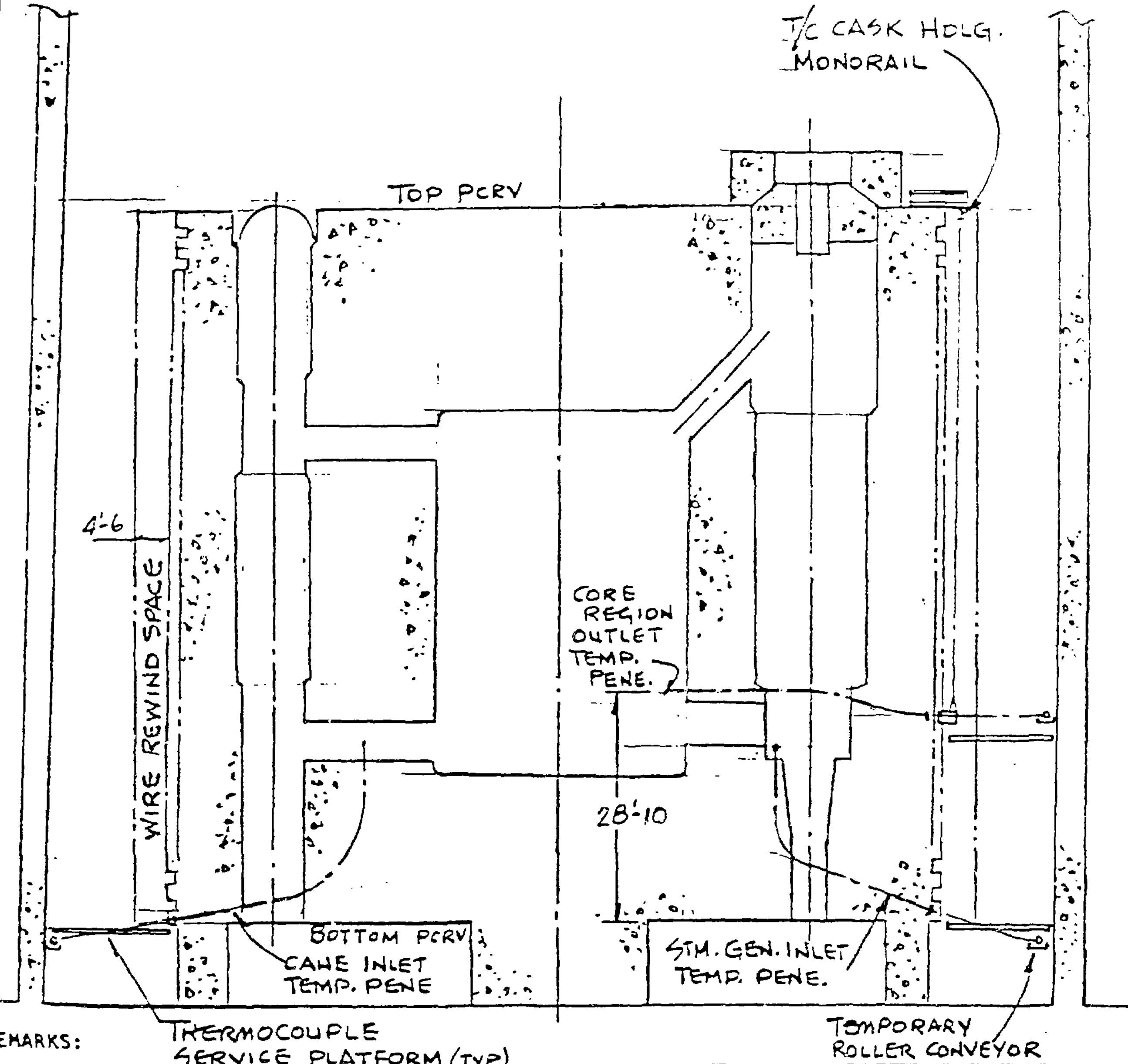
GENERAL ATOMIC COMPANY

CALCULATIONS FOR HE TEMPERATURE AS CONTROL & PPS ACTUATION VARIABLE			
EQUIP. NO	PROJ. NO.	CALC. NO.	PAGE 1 OF 2
PREPARED BY DPG	DATE 12/8/81	REF. DOCUMENTS	
REVIEWED BY	DATE		
APPROVED BY	DATE		

HELIUM TEMPERATURE MEASUREMENTS ARE USED IN THE REACTOR TRIP AND MAIN LOOP SHUTDOWN CIRCUITS OF THE HTGR SC/C PPS. THE ATTACHED DRAWING SHOWS SENSOR REPLACABILITY FEATURES FOR SUCH MEASUREMENTS.

PLANT TYPE HTGR

PLANT LAYOUT REQUIREMENTS



REMARKS:

SECTION

PROJECT NO.	EQUIPMENT NO.	ISSUE
4275	R-1111	
MW(e) 900		SHEET 14 OF

D16

COMMENTS/QUESTIONS AND RESPONSE

NO. 11

SESSION IIC

ORG SMSC

ITEM Overall Plant Control System

REVIEWER K. R. Van Howe

REVIEW ITEM Helium Rate of Flow System

COMMENT/QUESTION

Why not use differential pressure across the orifice valve for each coore inlet region for the control of helium flow? Orifice position is not good enough for indication of flow.

RESPONSE

Because the differential pressure across the orifice is not sufficient data for flow measurement. The orifice valve position changes and the C_v changes with it.

COMMENTS/QUESTIONS AND RESPONSE

NO. 12

SESSION IIC (Deferred from IIA) ORG EG&G

ITEM Plant Protection System REVIEWER C. E. Forkel

REVIEW ITEM Document 903639, Pg 9, Paragraph 3.1.6.1

COMMENT/QUESTION

What is meant by, "The low plant helium flow setpoint is based only on the differential pressure across the main circulator inlet?" How is the differential pressure measured?

RESPONSE

This is really the differential pressure from the entrance to the bell mouth at the steam generator outlet to a point just ahead of the LIV.

COMMENTS/QUESTIONS AND RESPONSE

NO. 13

SESSION IIC (Deferred from IIA) ORG GE-ARSD

ITEM Core Auxiliary Cooling System REVIEWER J. Impellezzeri

REVIEW ITEM CACS Automatic Initiation

COMMENT/QUESTION

What reactor plant conditions/sensor signal levels initiate an automatic CACS startup? Could minor plant transients (i.e., interruption of power temporary, trip of feedwater pumps, etc.) put the reactor plant in an emergency mode by automatically initiating the CACS and isolating the primary loops? Evaluate PPS conditions/signal levels/effects that initiate CACS startup to insure a false initiation is minimized.

RESPONSE

CACS automatic initiation occurs on:

Low plant feedwater flow rate at ∿10% plant flow*
Low plant helium flow rate at ∿11% plant flow*
High containment pressure ∿20 psia*

Minor plant transients do not automatically initiate CACS. The limiting safety system settings are chosen far enough below power operation flow levels and far enough above power operation pressure level to preclude initiation by minor transients.

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*preliminary values

COMMENTS/QUESTIONS AND RESPONSE

NO. 14

SESSION IIC

ORG Various

ITEM Auxiliary Helium Circulator

REVIEWER Various

REVIEW ITEM Prevention of Reverse Windmilling & Brinelling

COMMENT/QUESTION

Various reviewers had raised questions concerning reverse windmilling of the auxiliary circulator and also the prevention of brinelling the bearings without consuming the life of the bearings.

RESPONSE

Possibly the best solution to this problem is to continuously drive the circulator in the forward direction at the lowest controllable speed (about 2%). The circulator will be in surge so there will be no net flow of helium around the CACS. This will prevent uncontrolled windmilling and protect the bearings without consuming their life. GA will take the study of this approach as an action item.

COMMENTS/QUESTIONS AND RESPONSE

NO. 15

SESSION IIC

ORG EG&G

ITEM Circulator Disk Test Plan

REVIEWER C. E. Forkel

REVIEW ITEM Document 905768, Pg 13, Paragrap 3.3.2d

COMMENT/QUESTION

How is it possible to bring out the leads from strain gages mounted on the circulator disks?

RESPONSE

This can be very easily done by bringing the leads through the centcr of the shaft to slip rings. This has been successfully done in the past.

COMMENTS/QUESTIONS AND RESPONSE

NO. 16

SESSION IIC ORG EG&G

ITEM Main Circulator Bearing & Seal Test REVIEWER C. E. Forkel

REVIEW ITEM Document 906252, Pg 8 Paragraph 2.6

COMMENT/QUESTION

Referenced Documents 906063 and 026801 should be furnished for review.

RESPONSE

GA will distribute the referenced documents.

COMMENTS/QUESTIONS AND RESPONSE

NO. 17

SESSION IIC

ORG EG&G Idaho

ITEM Main Circulator Bearing & Seal Test

REVIEWER C. E. Forkel

REVIEW ITEM Document 906252, Pg. 8, Para. 2.7.2. - Caution

COMMENT/QUESTION

Is this critical speed supposed to be a correlation with the prototype circulator? This seems not to be the case with the proposed test rig.

RESPONSE

The critical speed has to do only with the test rig - not the prototype.

COMMENTS/QUESTIONS AND RESPONSE

NO. 18

SESSION IIC | ORG DOE

ITEM Shutdown Seals | REVIEWER L. M. Welshans

REVIEW ITEM Code Qualification of Inconel 718

COMMENT/QUESTION

Why is Code approval of Inconel 718 needed at a cost of $800K? Can some foreign exchange data be used?

RESPONSE

This data has been very difficult to obtain. Some months ago, GA went through DOE to obtain the information that now exists on Inconel 718. A significant fraction of the needed information exists in that data base. What does not exist is the qualification of the welding of Inconel 718 as needed for the shutdown seal bellows. Therefore, additional work must be expended, but not as much as was originally estimated. The bellows becomes the primary coolant boundary when the shutdown seal is applied and, therefore, the welded material must be Code approved.

COMMENTS/QUESTIONS AND RESPONSE

NO. 19

SESSION IIC ORG DOE

ITEM Main Circulator Impeller REVIEWER L. M. Welshans

REVIEW ITEM Fracture Mechanics Data for Type 400 SS Forgings

COMMENT/QUESTION

What is the justification for the design data needed for fracture mechanics and crack propagation research on a large forging of the impeller material at a cost of $200K?

RESPONSE

This material is not Code approved because it is not normally used for pressure vessels. The data base for this Series 400 stainless steel does not include fracture toughness and crack propagation information. On Delmarva. there were a number of questions from NRC in this regard which remained unresolved. This data has not been generated in the five years since the negotiations with NRC.

COMMENTS/QUESTIONS AND RESPONSE

NO. 20

SESSION IIC ORG EG&G Idaho

ITEM Main Circulator Device Module REVIEWER C. E. Forkel

REVIEW ITEM Return and Supply Lines on Draw.026950

COMMENT/QUESTION

I am not able to tie the return and supply lines on Drawing 026950 with the sketch of the main helium circulator service connections. It would clarify the operation of the system if the attached figure were phantomed in the drawing to show the complete system.

RESPONSE

The viewgraph of this system used in GA's formal presentation provided the suggested information with great clarity. GA agreed as an action item to add the requested information or to substitute the viewgraph drawing.

attach to comment on Dwg 026950

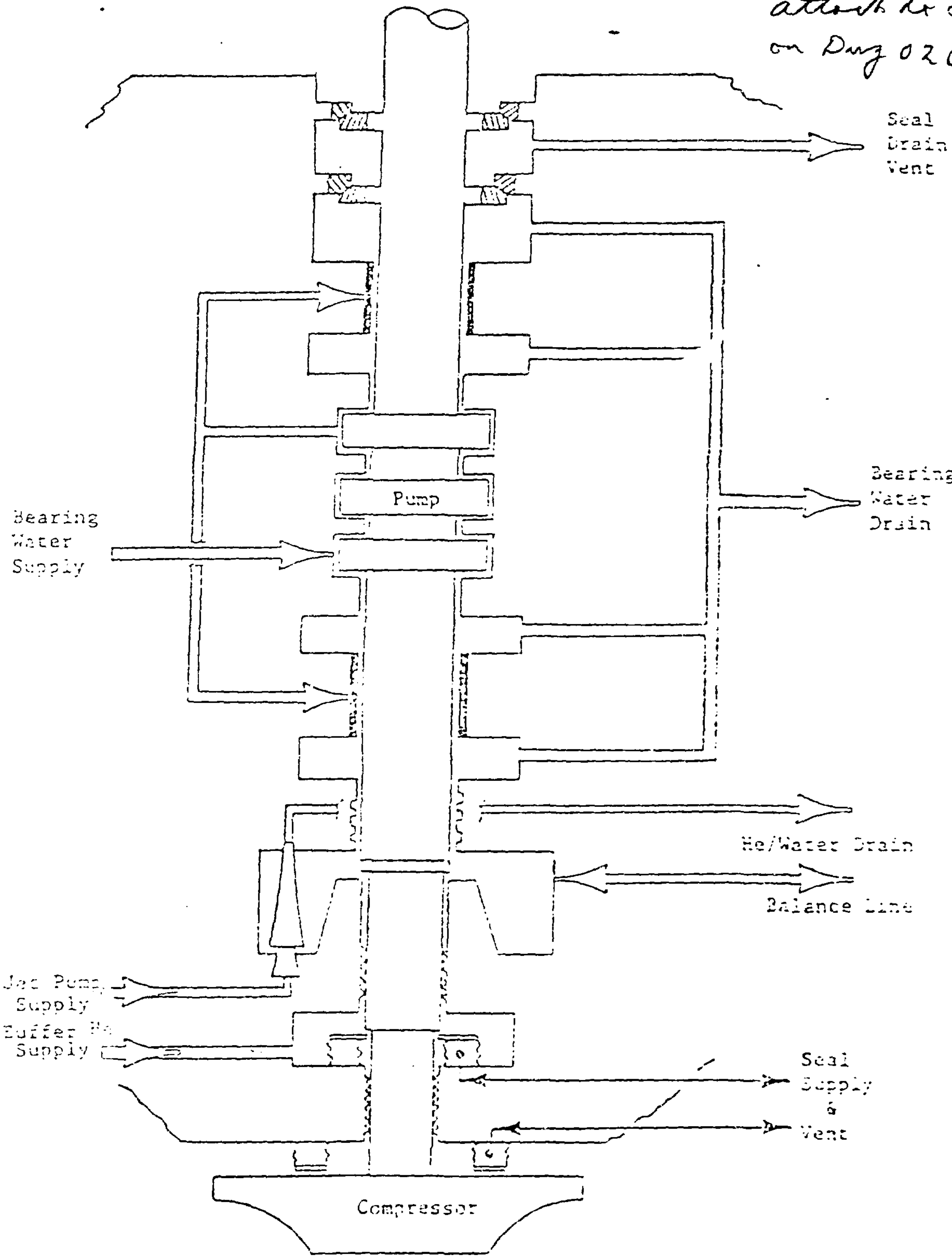

FIG. 1 - MAIN CIRCULATOR SERVICE CONNECTIONS

COMMENTS/QUESTIONS AND RESPONSE

NO. 21

SESSION IIC ORG EG&G Idaho

ITEM Main Circulator Service Module REVIEWER C. E. Forkel

REVIEW ITEM Area D1 on Draw. 026950 - Supply Helium

COMMENT/QUESTION

What repressures the supply helium line to the "buffer helium cavity?"

RESPONSE

The helium is repressured by the helium compressor in the helium purification system. The supply helium is taken from a purified helium header. The supply helium does not return to the circulator directly from the main circulator service module.

COMMENTS/QUESTIONS AND RESPONSE

NO. 22

SESSION IIC ORG DOE

ITEM Loop Isolation Valve (LIV) REVIEWER L. M. Welshans

REVIEW ITEM Mechanical Override on Operation of the LIV.

COMMENT/QUESTION

Wouldn't it be possible to provide a mechanical override on the valve to assure its operation?

RESPONSE

There were a number of studies of mechanical linkages on the gas cooled fast breeder reactor (GCFR), and it is very difficult to make this a reliable system. One of the more serious problems is that of providing a seal against the high pressure helium. A study has recently been undertaken on a mechanical actuation for the valve, but it is difficult to argue against the success of the FSV valves. These have thousands of hours of successful operation in the reactor, and have been improved by the addition of the pneumatic override. GA believes the force applied by the helium jet is more than could be applied by a mechanical linkage. The radius of the jet is three feet, and with a pressure of 1000 psi, it would appear possible to shear the shaft. One concept that is being considered is to use a pelton wheel which would have a series of buckets upon which the jet would impinge. GA agreed as an action item to perform a thorough analysis on whatever system is selected.

COMMENTS/QUESTIONS AND RESPONSE

NO. 23

SESSION IIC

ORG Unknown

ITEM Circulator Prototype Test

REVIEWER Unknown

REVIEW ITEM Technology Program Costs

COMMENT/QUESTION

What is included in the costs for the technology program? Are the motor and its controller included?

RESPONSE

The hardware and capital costs include the facility, the circulator hardware, the service system hardware that stays in and around the test vessel, but they do not include the motor and its controller. The motor and its controller cost $1.2M and $2.0M, respectively.

COMMENTS/QUESTIONS AND RESPONSE

NO. 24

SESSION IIC ORG GCRA

ITEM Main Helium Circulator REVIEWER R. A. Evans

REVIEW ITEM Selection of Circulator and Drive Motor

COMMENT/QUESTION

1. Was 3600 rpm (or higher) speed considered in optimizing the circulator and motor selection?
2. Is there an overspeed requirement for the circulator?
3. What is the margin for continuous overspeed and/or overload if required to increase the helium flow to increase plant output?
4. What is the overvoltage margin in the solid state controller output?

Consider including at least 10% margin in circulator system performance to insure attaining the full output of the plant.

RESPONSE

1. Higher speeds were considered but with a centrifugal circulator there is a loss of efficiency by going beyond the optimum specific speed; 2360 is a compromise where it would be lower, but the impeller gets too big. Higher than 3600 rpm would go to 5000 to 6000 rpm with axial flow; however, it was felt a more conservative technology on the motor would be preferred. The axial flow diffuser would also require a deeper penetration in the PCRV.
2. The circulator has been designed with a very conservative tip speed. It has an overspeed capability of about 30 to 40%. At FSV, the overspeed capability is about 50 to 60%; it has operated as 40% overspeed.
3. The motor is designed for 15,000 hp at 2360 rpm, including 20% rate of flow margin at the worst combination of system differential pressure and flow. Nominal power would be more like 14,000 hp. There is no margin over the motor nameplate power.

NO. 24 Continued

The circulator will meet the uncertainties of flow and pressure drop specified by the system group including a 9% overflow capability (over the nominal).

4. The power supply will provide 110% of the nominally required frequency and voltage to match the boundaries of the circulator in power and tip speed in the worst case.

COMMENTS/QUESTIONS AND RESPONSE

NO. 25

SESSION IIC (Deferred from IIA) ORG CE

ITEM Circulator PM & ISI REVIEWER A. L. Gaines

REVIEW ITEM Document 903637, Pg. 6

COMMENT/QUESTION

What provisions are made for circulator preventative maintenance (PM) and in-service inspection (ISI)? These questions show why the CACS should be included in this description.

RESPONSE

There was considerable discussion over this question. The containment aspects of the matter will be treated along with the rest of the containment such as visual inspection of the closure bolts. From the FSV experience, certain components will probably be volumetrically examined when the circulators are removed. The sliding seals are expected to have a maintenance schedule of four to five years and the bearings a longer time. The net result is that the PM and ISI requirements are yet to be developed.

COMMENTS/QUESTIONS AND RESPONSE

NO. 26

SESSION IIC (Deferred from IIA) ORG CE

ITEM Circulator Pt. of Surge & Brgs. REVIEWER A. L. Gaines

REVIEW ITEM Document 903637, Pg. 15, Paragraph 3.7.4.2

COMMENT/QUESTION

The "point of surge" requires better explanation. Compressor Bearings should be outside primary pressure boundary (out-board of seals). Therefore, the fluid should be left to compressor designers choice. If this cannot be accomplished, then helium gas bearings should be seriously considered.

RESPONSE

The consensus of the group was that this item had been adequately covered during the formal presentation by Mr. Kapich.

COMMENTS/QUESTIONS AND RESPONSE

NO. 27

SESSION IIC (Deferred from IIA) ORG CE

ITEM Circulator Inlet & Diffuser REVIEWER A. L. Gaines

REVIEW ITEM Document 903637, Pg. 16

COMMENT/QUESTION

Inlet & Diffuser design for maximum rather than a minimum differential pressure is confusing.

RESPONSE

This has to do with the structural strength of the actual ducts not a performance requirement. The diffuser interior contains high velocity, low pressure helium and it is surrounded by low velocity, high pressure helium which require design for the maximum differential pressure across the diffuser wall. Similarly, the inlet duct interior contains the lowest pressure helium in the entire loop while its outside is subject to the highest pressure helium in the entire loop.

COMMENTS/QUESTIONS AND RESPONSE

NO. 28

SESSION IIC

ORG ORNL

ITEM Main Helium Circulator

REVIEWER P. Kasten

REVIEW ITEM Design Pressure Rise

COMMENT/QUESTION

The pressure rise is specified as around 22 psi. One 900 MW document states the loop pressure drop is 17 psi. Is this because the system is 1050 psi instead of 700 psi?

RESPONSE

For the 2240 MW(t) HTGR - SC/C plant, 22.9 psi is the limiting value with maximum margin stack-up for a design basis.

COMMENTS/QUESTIONS AND RESPONSE

NO. 29

SESSION IIC ORG CE

ITEM Primary Pressure Boundary REVIEWER A. L. Gaines

REVIEW ITEM Document 903638, Pg. 15, Paragraph 7.0

COMMENT/QUESTION

Why is the auxiliary circulator part of primary pressure boundary? Figure 7-1, p. 28, shows penetration closure contains entire unit. Last paragraph states services not safety related, including oil service to the bearings. How long can circulator run without oil service? Could failure of service contaminate oil reservoir or drain it? Where is transition between safety classes?

RESPONSE

The auxiliary circulator is completely within the pressure boundary and is not a part of the closure except for the part labeled in Figure 7-1 "Auxiliary Circulator Primary Closure." The auxiliary circulator can be operated isolated except for cooling water which is safety classified. The lubricating oil is self contained; the oil service module is actually a cart which is used for the periodic changing of the oil. The circulator can be operated in an emergency without a supply of buffer helium.

COMMENTS/QUESTIONS AND RESPONSE

NO. 30

SESSION IIC ORG CE

ITEM Aux. Circ. Opening Torque REVIEWER A. L. Gaines

REVIEW ITEM Document 903638, Pg. 17, Paragraph 9.0

COMMENT/QUESTION

Is opening torque at 6% frequency adequate?

RESPONSE

An opening torque of 6% is adequate to open the auxiliary loop isolation valve (ALIV) at pressurized conditions.

COMMENTS/QUESTIONS AND RESPONSE

NO. 31

SESSION IIC ORG DOE

ITEM Reactor Service Equipment REVIEWER L. M. Welshans

REVIEW ITEM Design, Seismic and Safety Classifications of Large Reactor Service Equipment Casks

COMMENT/QUESTION

The large casks that interface with the primary coolant system during maintenance are being designed to Section III Div. I, QA Level II, Seismic Category I, and Safety Class III Requirements. These requirements not only add to the design and equipment costs but may reduce plant availability if NRC requires that the equipment be tied down when coupled to the PCRV openings (this condition exists at FFTS). GA should (1) review the design requirements for these items of equipment, (2) determine if brief exposure of primary coolant to containment atmosphere during shutdown for maintenance is acceptable and downgrade the equipment classification accordingly.

RESPONSE

1. GA will review the design requirements and document the reasons.
2. The exposure of the coolant to air is not acceptable because this allows air to enter the primary system and contaminates the containment.

COMMENTS/QUESTIONS AND RESPONSE

NO. 32

SESSION IIC ORG SMSC

ITEM Reactor Service System REVIEWER K. R. Van Howe

REVIEW ITEM Inservice Inspection (ISI) Requirements

COMMENT/QUESTION

It does not appear that ISI requirements and concepts will be defined until start of preliminary design. This may have significant impact on the plant design and availability, and should be factored into plant conceptual design. Accelerate ISI development program to allow incorporation into conceptual design phase.

RESPONSE

The need for ISI provisions is recognized by GA. It is included in the program plan.

PART E

REVIEWERS' CAUCUS

PART E

REVIEWERS' CAUCUS

The attendance at the Reviwers' Caucus is shown on the attached list The results of this part of Session IIC will be detailed in the moderator's report.

HTGR

SESSION II C. – Circulators, C & I, [illegible]

CAUCUS

NAME	ORG.
C. E. FORKEL	EG & G
F. E. Swart	GCRA
V G Scotti	CE
C. DUPEN	C-E
PAUL KASTEN	ORNL
W. H. ROACH	EG & G / IDAHO
R. F. Stearns	Bechtel
MERWIN BROWN	ARIZONA PUBLIC SERVICE CO
H. L. Gotschall	GCRA
John Gurley	G.E. ARSD