DPST-85-370

PSP PROGRAM CLOSE OUT DOCUMENTATION

DPST-85-370

PSP PROGRAM CLOSE OUT DOCUMENTATION

AUTHORS:

K. Andringa
H. E. Hootman
A. S. Ferrara
P. K. Smith
J. W. Congdon
H. W. Randolph
R. H. Young
F. E. Driggers
S. V. Topp

TABLE OF CONTENTS

TABLE OF CONTENTS CONT.

I. HISTORY AND OVERVIEW

In December 1982 DOE-SR directed SRL[1] to study the feasibility and impact of a program to lower the U-236 content of the Highly Enriched Uranium (HEU) stockpile used as fuel for the SRP reactors. In response to this request SRL assessed four technologies, Atomic Vapor Laser Isotope Separation (AVLIS), Molecular Laser Isotope Separation (MLIS), Gas Centrifuge, and the Plasma Separation Process (PSP) for this purpose with the assistance of the Engineering Department. In April 1983 cost/benefit analyses for these processes, high spot cost estimates for production facilities, and process uncertainties were submitted to DOE-SR[2] with a recommendation to proceed with the conceptual design and supporting development programs for a facility based on the use of the PSP process. The current program status for the PSP development program at SRL and the design and documentation of a production facility at SRP, referred to as the Fuel Improvement Demonstration Facility (FIDF), is described in this report.

Overall responsibility for the program at Savannah River rested with SRL until September 1984. This included:

- Development program liaison with TRW.
- Providing Technical Data Summaries and Basic Data documentation for conceptual design and cost estimates.
- Liaison with SRP and Engineering Department for FIDF design.
- Development of balance of plant processes and equipment for the FIDF.

In September 1984 responsibility for the FIDF project and project liaison were transferred to SRP.

The development of the balance of plant processes and equipment had the following major objectives:

- Development of a fabrication technology for PSP source assemblies suitable for the FIDF.
- Demonstration of key elements of source assembly fabrication at SRL.
- Selection of collector materials and coatings for the FIDF separator module and of a coil liner material.
- Development and demonstration at SRL of components and material handling operations for the FIDF.
- Installation at SRL of a Components Test Module (CTM) allowing sustained operation of major separator components and subsystems at full process power with depleted uranium.

- Transfer of PSP technology from TRW to Savannah River and training of SRL/SRP personnel.

The development and selection of source fabrication technology has been approached by funding Rocky Flats and Oak Ridge for uranium casting and uranium to copper brazing. These activities are reported in Sections V-1 and V-2. An SRL facility to demonstrate the selected brazing and associated activities is outlined in Section V-2.5.2. Preparations for a project to design and install this facility in the "hot machine shop" were terminated by the termination of the PSP program. Work aimed at selection of an acceptable coolant and cooling system for the separator module internal components is reported in Section V-3.

The CTM was to be the facility at SRL where technology transfer, personnel training, separator subsystem testing as well as component handling and refurbishment operation would be implemented. A facility design and installation project was written and submitted to DOE-SR for approval. Process equipment for the CTM installation was designed and built by TRW. Project documentation is detailed in Section VI.

In February 1985 DOE-SR directed SRL to bring all PSP activities to an orderly conclusion(3).

II. COST BENEFIT ANALYSES

From time to time, estimates have been made of the benefits (value of production gains) associated with the use of PSP to reduce the U-236, U-238, and U-234 content of SRP highly enriched fuel. For any assumed scenario of SRP reactor operation and replacement fuel supply, a fairly accurate estimate can be made of these production gains using PSP. However, there are significant uncertainties in the projected operating scenarios. The two most significant uncertainties in predicting production losses without PSP, which form the base for evaluating production gains using PSP, are the number of reactors operating on highly enriched uranium (HEU) (most importantly on tritium production) and the supply of make-up HEU.

The basis for estimating production gains is reviewed in DPST-83-208[4] which also gives some early estimates of these gains and their value. A detailed analysis of fuel composition and production losses, with and without PSP, is given in DPST-83-1008[5] for several reactor scenarios. These results are expanded in DPST-84-257[6]. The most recent cost benefit studies have been reviewed by J. S. Allender.[7].

III. CONCERNS AND RECOMMENDATIONS

The following items represent issues which have either not been resolved or are of concern in the PSP program as implemented at Savannah River. Attention must be given to these issues if and when planning for a production facility is taken up again at some future date.

- Selection of an acceptable coolant for the internal components of the separator module.
- Gyrotron development.
- Demonstration of components handling and refurbishing.
- Liaison between Engineering Department, TRW, SRP and SRL.
- Magnetic field safety and personnel exposure.
- Receiving and accounting of depleted uranium.

Coolant Selection

The module components for the development program at TRW are all cooled with deionized water. In order to transmit 200 kW of microwave power at 140 GHz frequency through an air filled waveguide to the evacuated module bore tube a microwave window is planned which is face-cooled with a fully fluorinated fluorocarbon. The source assembly inside the bore tube, the drive coil, and other internal module components would also be cooled by the same or a similar fluorocarbon in order to alleviate criticality concerns.

A study of the hazards arising from the possible interaction between high temperature uranium and fluorocarbon, as well as from possible fluorocarbon decomposition products produced by exposure to temperatures between 500°C - 700°C, has raised questions which are significant enough to consider cooling with heavy water in closed, small volume systems. Documentation is presented in section V.3.

Gyrotron Development

The FIDF point design requires 200 kW of microwave power at 140 GHz (2.1 mm wavelength). There is currently no existing device or technology which provides this amount of continuous power at this wavelength. DOE is funding the Varian Microwave Tube Division in Palo Alto through Oak Ridge National Laboratories and the Office for Fusion Energy to develop a gyrotron to satisfy these requirements. SRL and TRW have prepared a fallback position to operate the FIDF with 56 - 60 GHz microwave power at reduced plant throughput in case this development program is unsuccessful or delayed. TRW monitors the Varian contract for the PSP program. A conceptual design review was attended at Varian on September 24-26, 1984. It is clear that the gyrotron development program schedule is extremely ambitious and optimistic. Some basic technology in generating high powers at these high frequencies remains to be demonstrated, and even if successful the schedule will probably not be met.

Components Handling and Refurbishing

Significant issues of handling and refurbishing Module Components loaded with HEU in the FIDF remain to be resolved. SRL intended to address these issues in the CTM installation in a non-prototypic layout. No actual handling demonstration was made because the CTM project was not implemented. Urgent attention to equipment refurbishing operations is needed when the FIDF project is resurrected at a later date. A revised, more prototypic CTM layout is desirable for this purpose.

Several Basic Data and Scope Development issues were raised by the Engineering Department in a letter to H. E. Hootman dated January 25, 1985 and included in this report as Appendix A.

Program Liaison

The liaison between sites involved in the PSP program and FIDF project has become increasingly cumbersome as the start of an FIDF project approached. There has not been a sufficiently close coordination between separator equipment design at TRW and facility and installation design at Engineering Department as well as between process equipment development at SRL and facility design at Engineering Department.

The direction and coordination of the three sites (SR, TRW, Engineering Dept.) should be improved.

Magnetic Fields

The FIDF separation module uses a 6 Tesla (60,000 Gauss) superconducting magnet in the form of a 7 meter long solenoid with 1 meter clear bore. The magnetic field lines outside the magnet bore can be calculated adequately, and personnel access can be controlled to satisfy DOE guidelines on personnel exposure limits to high magnetic fields. Additional precautions are in order for the following cases:

- personnel with implanted pacemakers which are sensitive to magnetic fields
- operation of equipment controls which are sensitive to magnetic fields, including relays, etc. Safety problems could arise from relays operating or failing to operate in the presence of a high magnetic field.
- Building steel can concentrate magnetic field lines in unexpected locations.

Receiving Depleted Uranium from Oak Ridge and Rocky Flats

Source assemblies fabricated from depleted uranium were shipped to SRL from Oak Ridge during the course of the development program. Reception procedures at Savannah River were often not implemented correctly, resulting in considerable administrative work. A memo was written to correct this situation but not issued due to termination of the program. It is included as Appendix I. A second difficulty is that SRL is accountable for depleted uranium to the nearest gram. Other DOE sites only report to the nearest 1000 gram. Shipping information is often incompatible with SRL requirements.

IV. FUEL IMPROVEMENT DEMONSTRATION FACILITY STATUS

At the request of DOE-SR[1], a cost benefit study[4] was made by SRL to determine the effect of removing the non-fissile isotopes of uranium from the highly enriched uranium stockpile used in SRP reactor charges.

A comparison of various isotopic separation processes was made with the assistance of the Engineering Department to obtain high spot cost estimates of the conceptual processing plants[2]. The PSP system of isotopic separation was chosen in preference to two laser systems (AVLIS and MLIS) and the gas centrifuge. Subsequently a design study was authorized to obtain a VGA cost estimate for a PSP processing facility to be built in the existing 305-M Building. A Technical Data Summary[8] was issued to assist the estimate. A single TRW Plasma Separation Process (PSP) unit was sized[9] such that successful development of the process would provide a 2 MT/year of throughput. Building modification provided space for electrical equipment, a refurbishing area, personnel support facilities, and a metal foundry for fabricating feed plates.

The Engineering Department completed the VGA cost estimate for the construction of this facility of $90 million based on FY-1983 dollars. This estimate[10] confirmed the earlier high spot estimate of the process comparison by the Engineering Department.

Further development of the design was authorized by the request for a CAC cost estimate. To support further design refinement, SRL reviewed the reference process for fabricating source plates[11].

Rocky Flats[12] and Oak Ridge[13] uranium foundries were visited and provided input to the basic data. Source plate brazing[14] and ultrasonic bond testing[15] work was also initiated at these two sites to provide additional basic data. TRW updated the module point design[16]. The Technical Data Summary[17] was revised to reflect changes that evolved during the CAC design development.

The Preliminary Safety Analysis[18] and an Environmental Evaluation Impact Analysis[19] were issued. The dose burden for full operation of FIDF was calculated[20]. An SNM accountability plan[21] and a functional description of the computer system[22] to control accountability was made.

A conceptual design report[23] has been assembled and the final cost estimate for the project was transmitted[24]. A project QA plan was drafted[25].

At this point, the project was postponed.

V. DEVELOPMENT PROGRAM STATUS

V-1 SOURCE PLATE CASTING

V-1.1 Casting at Oak Ridge, Y-12, Martin Marietta

In the PSP process uranium is sputtered in vacuum from a large, thin metal plate to provide a uranium source for the isotope separation process. In the past Oak Ridge had fabricated 24 square source plates with little evaluation of quality. All were made with depleted uranium for the development program at TRW.

The SRL reference source assembly at the end of the program was as follows:

- A sourceplate consists of six segments
- Each segment is cast to size in graphite molds
- Segment edges only was machined to size
- One face is electropolished before brazing
- Each segment is brazed to a copper plate o Each brazed segment is soldered to the heat exchanger assembly.

See References 11 and 17 for geometry and physical arrangement.

The fabrication techniques used in the Oak Ridge production foundry are not practical for application in glove box enclosures. Large, cast uranium ingots are cross rolled to 0.5" thickness and machined to a 24" square dimension. The resulting plates are dressed on both surfaces and brazed to copper plates. The brazed assemblies are soldered to the source heat exchanger at TRW.

For source plates for the TRW development program Oak Ridge had selected billet casting/cross rolling/machining over direct casting to size to avoid warping, porosity and large grain size in the metal[13,37]. Oak Ridge declined to work on the development of direct casting. However they provided SRL with a large amount of information regarding casting line layout, furnace design, mold design, crucible and stopper design, foundry practices and other consultation[14].

Specifications were written[38] for a modified Oak Ridge design for an induction furnace intended for installation in the SRL Source Assembly Fabrication Facility described in more detail in Section V-2.5.2 of this report. The design incorporated demonstrated features from furnaces at Rocky Flats as well as Oak Ridge.

Because of rapid progress in casting development at Rocky Flats feasibility of casting large thin uranium plates was considered adequately demonstrated, and the induction furnace was eliminated from the SRL facility.

V-1.2 Casting at Rocky Flats, Rockwell International

The Rocky Flats Plant (RFP) developed the production technique for source plates by direct casting to size. Thin uranium sections of rectangular shape as well as sections shaped according to the FIDF point design were made successfully. RFP also performed some additional experiments.

Tests included cast bonding uranium to thin copper plate, and direct casting of uranium on top of a heel that had been roll-bonded to copper(12). The latter technique was considered for multiple refurbishment of a DU sourceplate. Subsequently, only one showed some promise. Early trials with bare, copper plates resulted in deep alloying and penetration through the copper. Cold shuts and incomplete fill on colder surfaces was another problem and trials were terminated(15,39,40,41,45). Pouring uranium on top of a machined uranium heel cleaned with alcohol failed to produce a bond. A proposal to use a nickel wash on the uranium receiving surface (to initiate oxide film penetration) was tried and met with limited success(45).

V-1.2.1 Casting Methods and Equipment

Thin section casting involved two techniques: vertical static pour and centrifugal (spin) casting. Both methods used vacuum, induction melting furnaces of adequate size and capacity. Large furnaces in the Production Foundry were scheduled for static pour use and work priorities often caused extended delays. The static pour method employed an imbedded graphite mold about five inches below the bottom tapped crucible; the mold was located mostly within the induction coil for heating. Melt fell in a stream into the vertical cavity of the stationary mold. Melt and mold temperature were important variables to surface finish for either technique.

When spin casting, the mold was horizontal, about 10" out of the induction coil, and rotated during pouring. The arrangement was used in a smaller, development laboratory furnace(39). Potential advantages of centrifugal casting include:

- Localization of contaminants at the casting's edge
- Minimal porosity and shrinkage, liquid was force fed from the central melt
- Finer grain structure

Disadvantages were the requirement for a preheated mold shorter mold life, and slightly higher cost of the furnace.

V-1.2.2 Casting Conditions

More than 25 acceptable castings demonstrated the technique of static pours(45). The range of conditions were:

STATIC POUR

Melt Temperature	1300 - 1500°C
Mold Bottom Temperature	510 - 1160°C
	700 - 900°C Preferred Range
Vacuum Level	4 - 45 Millitorr
Cycle Time	40 - 81 Minutes

CENTRIFUGAL CASTING

Melt Temperature	1350 - 1375°C
Rotational Speed	0 - 50 RPM
Mold Bottom Temperature	225 - 250°C
Vacuum Level	<10 - 40 Millitorr
Cycle Time	47 - 74 Minutes

Air leaks into the furnace caused by old gaskets prevented successful castings for an extended time. Gas in the melts repeatedly caused large surface blowholes and dimples until vacuum levels dropped below 50 millitorr(40,42,45). Trials with substitute gaskets were not successful and special shaped gasketing had to be made. Finally, rotary mechanism seals had to be replaced. When operable, scheduling of this furnace was not a problem.

V-1.2.3 Mold Design

The mold, schematically shown in Figure 3 of Reference 39 was first used for cast-bonding tests. When casting bare plate, the copper was omitted and equal width cavities in each insert were used.

The first four static castings were made with molds that had been hand painted with an yttria wash. Cast surfaces reflected every brushmark, and grooves up to 0.006" deep were apparent. Spray coating between pours was adopted as the standard procedure for both casting techniques. New molds were sprayed, air dried, fired empty in vacuum to intended use temperature (900°C-typically), cooled, inspected, and sanded if required. They were resprayed and air dried for repeated use with molten uranium. Typical lifetime varied between 16 and 20 castings per pair of inserts before the base coating became porous or fragmented.

Plate mold design for centrifugal castings is shown in Reference 39. Details of others, e.g. 12" dia. round, 20" dia. round, and 12" X 21" X 3/8" plate, etc., are shown in References 42 and 45. Life expectancy was about 3-5 pours less than static molds, 13-15 castings per bottom mold insert. Potential for scuffing the yttria was higher than in static casting.

V-1.2.4 Product Characteristics

The quality of plate surfaces improved with each casting campaign. After changing to spray coating and using a midrange mold temperature, surface texture was at least equal to machined Oak Ridge plate (125 RMS finish)[42,45]. Closeup surface detail can be seen in the last report for both static pours and centrigual castings. One other problem in the first casting series was cracking[43]. One plate cracked; the crack penetrated from one face to the other and was about one-inch long. Carbon, a cause of solidification cracking, showed normal in an analyzed sample from the edge. Unless local carbon content or temperature conditions were abnormal the crack was probably caused by handling.

Increasing the bottom temperature of a static mold above 900°C caused more rapid U attack and degradation of the yttria wash, and poorer surfaces. Test temperatures were as high as 1180°C, see photos attached to Reference 44. A restrictive program schedule and extended problems with seals prevented installation of thermocouples for temperature measurement in the spin cast furnace.

Typical uranium grains for static pours showed uniform axis dimensions of about 0.100". TRW expressed concern that one plate thickness consisted of as few as four to five grains. If a single crystal were to erode preferentially, copper penetration would cause premature failure. Spin cast plate had grains half that size due to more rapid solidification.

Rectangular and pentagonal center plates shrunk less than 0.025" upon solidification. The feather edge formed by the joint between mold halves and the riser, or feed pipe for the casting, required machining. For the circular sectors an average of five measurements across chords was 0.3" undersize[45] due to premature solidification and shrinkage; the range was -0.28" to -0.328".[13] A potential solution is to invert the mold cavity design so the wider portion (chord) would be fed liquid from the riser and not the central portion of the thin plate.

V-1.3 Recommendations

Plasma tests at TRW were scheduled and should be rescheduled to demonstrate the adequacy of cast metal structure and to evaluate creep and erosion resistance of a segmented plate. Plates of 11.5" square X 3/8" thickness and made from DU were required for brazing to a 1/8" thick Cu backing plate at Oak Ridge. Separator tests were scheduled for TRW's 0.5 meter module.

One whole plate and a plate with four 5.63" square, segments were shipped and awaited testing when the program ended. They had been made from the first pours and surface quality was relatively poor.

At the program's end, inversion of the mold cavity had not been tried to resolve undersize chords of the production sector. Minimum riser width should be determined for all shaped castings to decrease inventory and recycle quantities of enriched uranium. If this were developed together with grooved risers (parallel to the edge), mechanical breakoff may be possible and minimize dress machining requirements.

With the program delay, further investigation of centrifugal casting is recommended. The limits of casting and aspect ratios (width/thickness and depth/thickness ratios, respectively) for this technique should exceed static pouring and allow for casting versatility[46]. Casting two sectors simultaneously may be practical with a narrow interconnecting channel for a riser. A shaped downpour graphite insert in that channel to split flow and deflect the poured stream would minimize erosion of the coating and ease replacement. This approach may be precluded for high assay material because of inventory limitations for current conceptual designs for the FIDF casting operations.

V-2. BRAZING OF SOURCE PLATES

V-2.1 Background

Requirements for and conceptual design of the source assemblies are described in the Module Point Design document[16]. The Oak Ridge Y-12 Plant (OR) has been supplying brazed uranium-copper source plate assemblies for PSP development at TRW since 1979. These plates are made from wrought and machined uranium using large foundry scale equipment[14,47]. Copper-uranium plate assemblies are brazed one-at-a-time at 900°C in a large vacuum furnace over a four day heating cycle. Until recently the uniformity and strength of the brazed bond have not been assessed, nor the plates subjected to the high heat fluxes planned for SRP. Optimization of the fabrication process and bond characterization are not required for the development of the TRW separator. Consequently, the present equipment, techniques, and braze alloy represent the first expedient fabrication process that worked. Although the technology must be modified, the existence of this braze-bonding process and the successful use of large brazed plates in the TRW separators provides assurance that brazing can be adapted to join U and Cu in the FIDF.

V-2.2 Objectives

A development program was initiated to modify substantially the Oak Ridge technology for accommodation in the FIDF. The Oak Ridge equipment is large, expensive and difficult to operate in containment. Because of the required throughput of enriched uranium and the corresponding criticality concern, brazing cycles must be decreased to make six plate segments per shift instead of one large plate every four days. A lower temperature braze alloy than Gapasil* (845-880°C) is advantageous for lower heat loads in containment, lower temperature gradients, and faster furnace cycles. Brazing techniques are required that minimize machining of the uranium plate or segments before and after brazing.

Uniform coverage by the alloy must be assured. A non-destructive technique is required to measure the number and size of non-bonds after brazing to ensure good heat transfer. The bond strength must be adequate to withstand shear stresses from differential shrinkage of Cu and U and the axial temperature gradients through the plate arising from high heat fluxes. Finally, a melt separation technique is desirable to separate the U heel from the Cu backplate in

*Product of WESGO Division of GTE Products Corp.

backplate in containment for recovery of the uranium and to minimize scrap.

The overall objectives are:

- To bond U and Cu plates with enough strength and uniformity to withstand thermal stresses and high heat flux.
- To develop simple processes and equipment accommodating space limitations, low accessibility in containment, high throughput, and minimum waste.
- To choose a brazing technique to facilitate separation of spent U from Cu by remelting the braze alloy.

V-2.3 Scope of Work

The development program can be divided into three areas: Braze Metallurgy, Brazing Technique, and Testing of Plates. The Oak Ridge Y-12 Plant, Rocky Flats (RFP), TRW, and SRL were participants in development activities.

"Braze Metallurgy" entails the selection and characterization of alloys, determining the efficacy of fusion and solid state diffusion bonds, parametric testing to show process conditions producing optimum metallurgy, identifying conditions for bond cracking, and demonstrating melt separation. In "Brazing Technique," the emphasis is on adapting the existing technology and developing alternative approaches to fusion and solid state bonding. Cast, rather than wrought and machined plates, were brazed. The fixture used in the OR process was redesigned to increase throughput and uniformity of temperature. Solid state diffusion bonding was demonstrated both by vacuum hot-pressing followed by forging-rolling and by hot isostatic pressurization (HIPping). Brazing of plate was being demonstrated using induction-heating pressure-bonding (IHPB). The scope of "Plate Testing" included burnout calculations to establish the size of a non-bond that can be tolerated, development of ultrasonic inspection, plate tests in TRW separators and the CTM at SRL, burnout heat flux tests and creep tests.

V-2.4 Braze Metallurgy

V-2.4.1 Brazing Alloys

Gapasil

Gapasil-9 is a silver-based alloy containing 82% Ag, 9% Pd and 9% Ga with a brazing range between 845 and 880°C. It was selected by TRW and OR about six years ago based on short-term sessile-drop tests of the ability of a variety of braze alloys to wet uranium[48]. Initial tests, using a fixture containing a gas bladder to fit the contours of the surfaces, were successful in producing source plates. No further assessment or improvement in the alloy or technique was required until a simpler, optimized, production process was required by SR to withstand higher power densities over larger areas than heretofore tested. Gapasil-9 is the reference braze alloy for the FIDF because of its successful use for several years in about thirty source plates at TRW[14,48,49].

A typical microstructure of a braze made at OR with Gapasil is shown in Figure V-1. A two-mil-thick foil of braze has reacted into both the Cu and the U to form zones 5 to 15-mils thick. The alloy is effective in bonding Cu to U. This heavy reaction produces primarily Cu_5U as a brittle phase dispersed in copper-silver eutectic. The microhardness of the Cu_5U was measured as three times that of U which is, in turn, three times harder than that of Cu. The thickness of the braze zone is not particularly uniform. Regions occur along the braze wherein "breakaway" reaction has occurred to produce unusually wide reaction zones especially rich in Cu_5U compound. Voids up to a few mils across are usually associated with these "breakaway" reaction sites and occur at the braze-Cu interface.

Microprobe analyses across a typical Gapasil braze are shown in Figure V-2. These data show the absence of diffusion of constituents into uranium. This is desirable for recycle of the uranium. The analyses also show the preferential diffusion of about half the Ga and appreciable Ag up to four mils into the copper. This loss of braze constituents and the volume decrease on shrinkage probably explain the periodic voids that occur along the braze and those voids that occur primarily on the copper side where "breakaway" reaction has occurred. As constituents are lost from the braze, subsequent shrinkage on cooling must produce void. Figure V-3 shows diffusion zones in the copper opposite voids, indicating that braze occupied the void volume during brazing. These voids are too small to threaten burnout.

Figures V-2 and V-3 and observation of etched microstructures show that Pd is located in the braze and has not moved from its original position. Palladium is not needed; it is not involved in bonding and its presence raises the melting point of Gapasil.

Before metallographic analysis it was thought that braze in the outside of a source plate was overreacted compared to the center because of the estimated 75°C temperature gradients from outside-to-center of the fixture during brazing at OR.

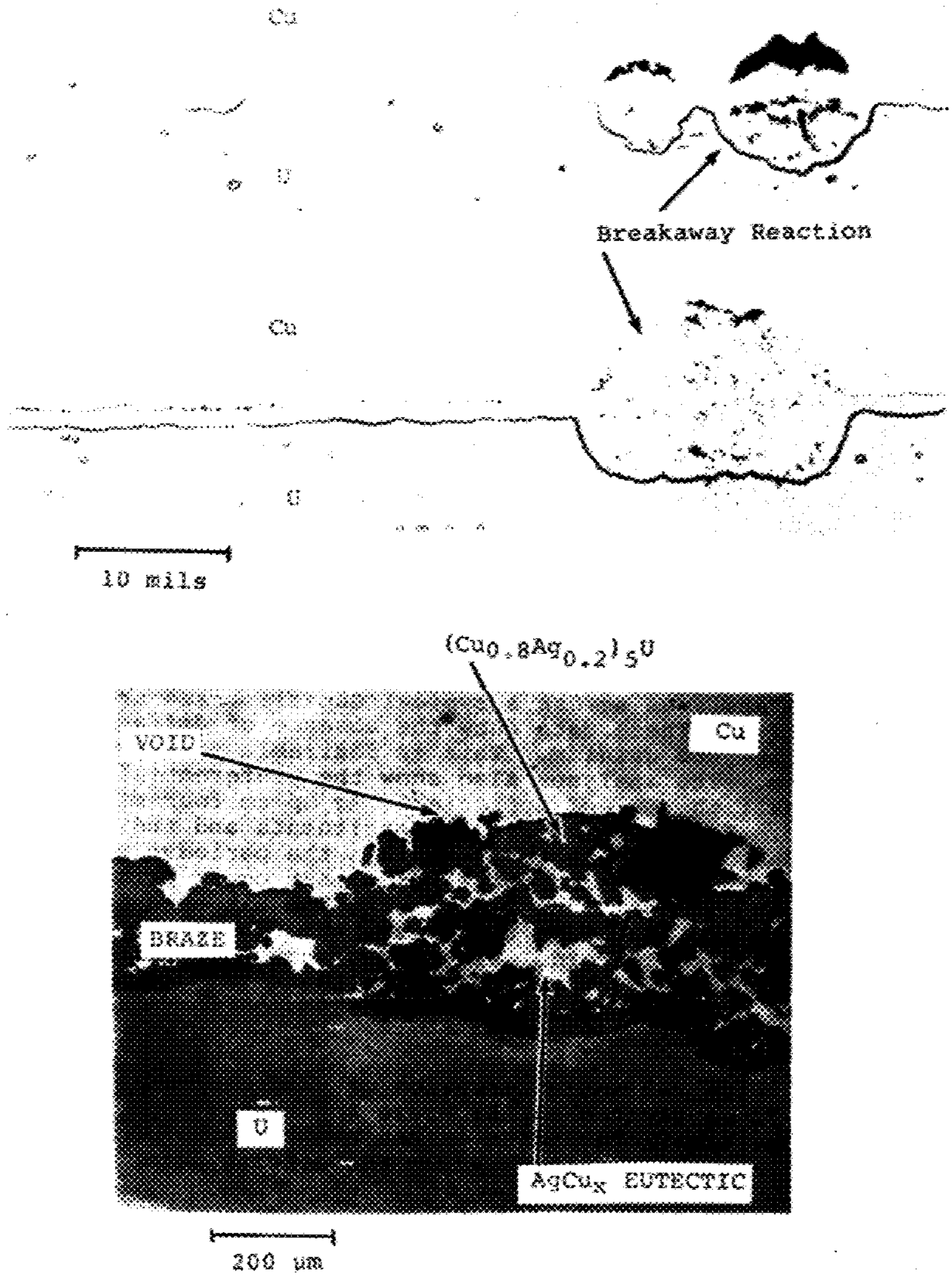


FIGURE V-1. Typical Gapasil Braze

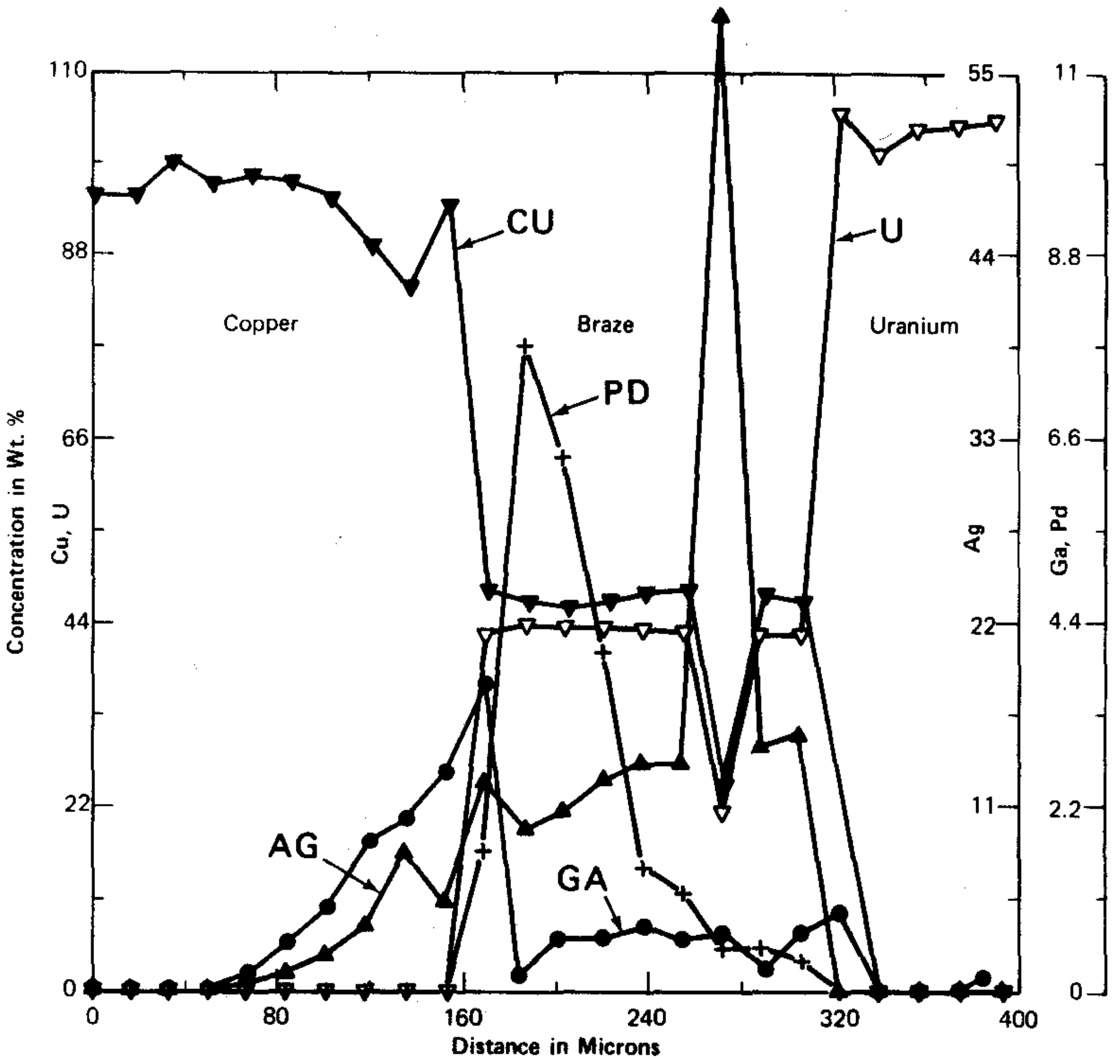


FIGURE V-2. Concentration Profiles Across Gapasil Braze

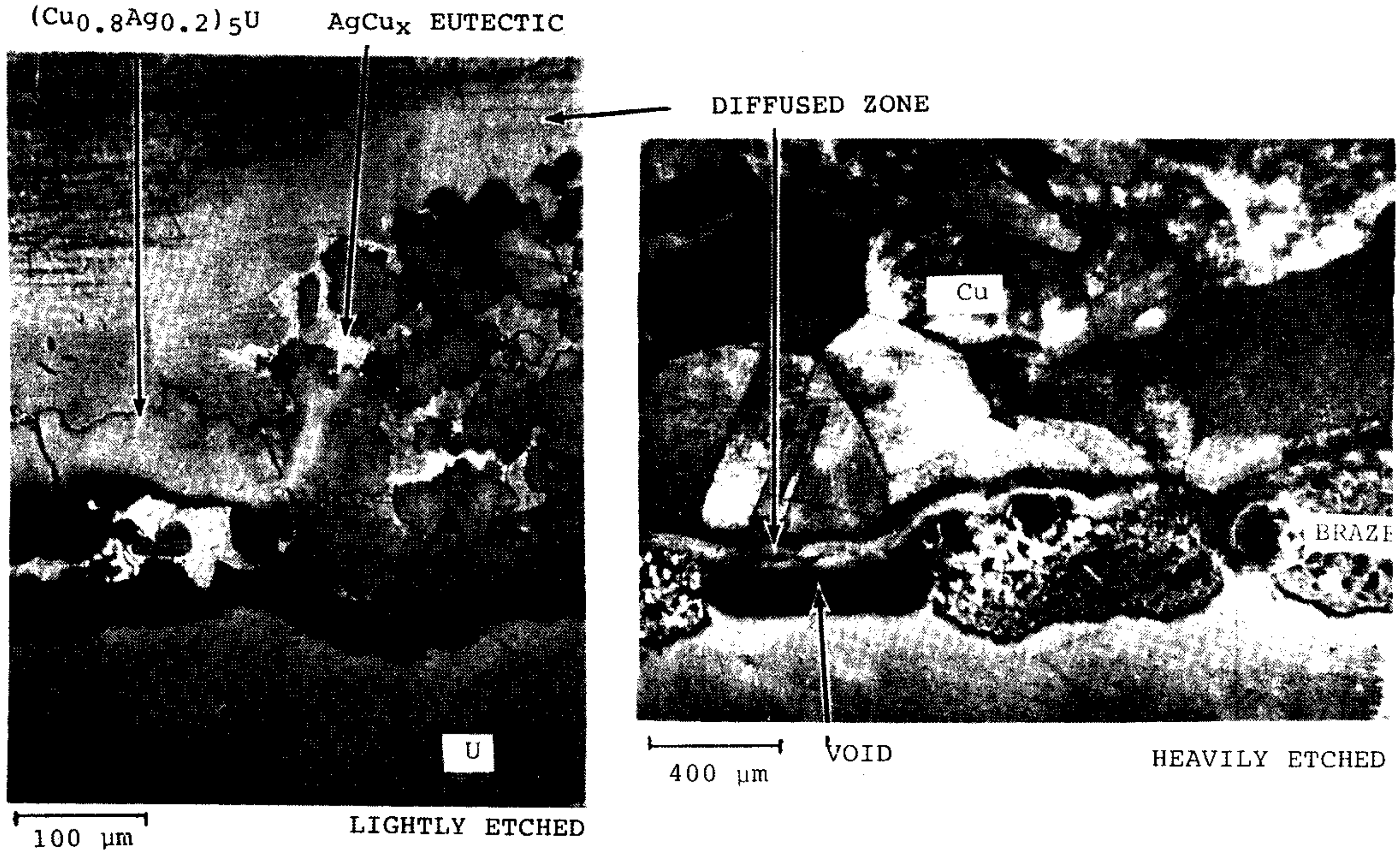


FIGURE V-3. Etched Gapasil Braze

However, serial metallography along a diagonal of an 11.5 inch square plate (as-cast uranium) and from side-to-side across an 11 1/2-inch-square plate (wrought machined uranium) showed the same good bonding, zone thicknesses, amount and zone thicknesses, amount and frequency of "breakaway" reaction, and incidence of small voids[50].

These observations suggest a number of characteristics about Gapasil. It is an effective braze to bond Cu and U but reaction does not proceed homogeneously. When some slow step phenomenon, such as fluxing UO_2, has been completed, braze alloy reacts rapidly. However, the thickness of the "breakaway" reaction zones is self-limiting apparently when the uranium content is saturated. Although reaction fronts are inhomogeneous, the extent of inhomogeneity is acceptable. Reaction is probably relatively insensitive to temperatures over a 100°C range and times between 30 min and 2 hrs. It is hoped that controlling temperatures within 25°C between 845 and 880°C and shortening brazing times to a few minutes will eliminate porosity, reduce "breakaway" reaction, minimize the Cu_5U brittle phase and provide for easier subsequent melt separation.

Alternative Brazing Alloys

Several other alloys were to lower the brazing temperature below the 845-880°C range for Gapasil[51]. The braze interface was calculated to operate below 300°C in the separator; so alloys were selected that melt above 600°C (for creep protection) and that contained no nuclear poisons or volatile elements harmful to the separator. The properties of the two silver-copper alloys and nickel that were selected for testing are shown in Table V-1.

TABLE V-1

BRAZING ALLOYS

Alloy	Composition	Brazing Temperature, °C
Gapasil*-9	12Ag; 9Pd, 9Ga	840-880 brazing range
Cusil*	28Cu, 72Ag	780 Cu-Ag eutectic
Cusiltin*-10	30Cu, 60Ag, 10Sn	718 Liquidus, 602 solidus
Ni	Ni	740 Ni-U eutectic

About fifty tests were made at RFP using these alloys to bond as-cast samples up to 4 inches square[51]. Brazings were done largely in a vacuum hot press. Temperatures varied from 25°C below melting to 50°C above melting and for times between

*Products of WESGO Division of GTE Products Corp.

10 and 90 min. Pressures varied from 25 psi to 300 psi. Ni was tested as sheet, electroplated spot arrays on copper, and continuous electroplated copper. (Electroplating was to control the geometry of assembly and to ensure surface fitup.) Samples were analyzed for non-bonds ultrasonically, then selected areas were cut out for metallographic and microprobe analyses and for coupons to measure shear strength.

Although these data are incomplete at this writing, certain observations can be made. All alloys bonded Cu to U when melted. Surface roughness in the as-cast uranium appears to require some pressure to effect fitup. (It was hoped that brazes would wet sufficiently to braze by gravity alone, and, hence, simplify the brazing equipment.) Ni reacts uniformly with U to form a well-bonded, homogeneously-thick, porosity-free, braze zone . The eutectic U-Ni composition was formed throughout the braze zone as indicated by microprobe analyses and by the two phase array of dendrites observed in the zone perpendicular to the braze plane. Silver-based alloys reacted evenly with both U and Cu and formed various amounts of the Cu_5U brittle phase observed in Gapasil. Cusiltin, because of its lower brazing temperature, and nickel, because of its simple chemistry and uniform reaction, are the most attractive alloys for further development.

V-2.4.2 <u>Microfracture in the Brazed Zone</u>

There is an insidious frequency of cracks observed in all brazes, both in large plates made at OR and in smaller test pieces at RFP. Ultrasonic analyses of 11 1/2-inch-square and 24-inch-square plates made at OR, and observation of mechanically separated samples, show a persistent recurrence of an intermittent band of non-bonds around the edge of the plates, penetrating about one-quarter-inch into the plates. These peripheral cracks occur at the Cu-braze interface. Most small test samples at RFP also exhibited some peripheral non-bonds on the ultrasonic traces.

Many RFP samples also exhibited extensive cracks within the interior of the plates and totally within the braze zone. These interior cracks did not appear on ultrasonic interrogation. All cracking was independent of the braze alloy used. Useful shear strengths of a few thousand psi were obtained even with cracked samples, and infer that cracks are intermittent. Considerably higher shear strengths should have been obtained if they were free of cracks.

The cause of these cracks is unknown. They could be related to shear stresses incurred by differential shrinkage of Cu versus U on cooling. The cracks within small samples at RFP were not observed in the interior of large plates brazed at OR, suggesting an effect in the technique or in scale. This problem is worrisome for both heat transfer and integrity of the bond in the separator.

V-2.4.3 Diffusion Bonds

The strongest bonds were obtained by solid state diffusion both without a braze and using nickel braze[43,52]. Hot-press bonding of ingots of Cu and U at 825°C and 850 psi for one hour produced a 4-mil-thick diffusion bond layer of Cu_5U compound with no voids nor cracks. Forging and repeated rolling to 12-inch-square plate with annealing at 850°C broke up the original brittle Cu_5U bond layer into discrete segments, but reformed more Cu_5U bond. If formed at the proper conditions to obtain some vertical integration of Cu and Cu_5U, shear strengths up to 80,000 psi were obtained. One problem of a direct Cu-U diffusion bond is the higher temperature (>940°C) required to exceed the Cu-U eutectic during melt separation. Equipment is also extensive and expensive.

Excellent solid state diffusion bonds were obtained by HIPping Cu and U plate with and without using Ni braze. HIPping was done at 15,000 psi and 825°C (Cu-U) or 725°C (Cu-Ni-U) for 2 hrs. Distinct diffusion layers of the phases in the Cu-Ni-U system formed in the braze zone that were pore and crack-free. Shear strengths of about 90,000 psi were obtained. But HIPping is only attractive if pressures less than 2000 psi can be used where equipment costs and safety are more attractive.

V-2.4.4 Parametric Tests

Statistically-designed parametric tests of brazing with Ni and Gapasil were initiated near the end of the program at RFP. The study for Ni will be completed and reported later[51]. These tests were designed to correlate conditions with braze quality. The tests used four-inch-square pieces in a vacuum hot press. Conditions of the study are: 25° and 100°C above melting, 5 min and 50 min melt times, 1 and 3 mil thick braze, 20 and 100 psi loads and electropolished or wire brushed U surfaces.

The study is intended to provide design information for selection of the brazing equipment. Particular emphasis is placed on short time and low temperatures to minimize the formation of brittle reaction phases, minimize porosity and preserve the composition of the brazing alloy for subsequent melt separation. Screening tests heretofore have been for longer times and higher temperatures producing braze structures that appear heavily reacted.

V-2.4.5 Melt Separation Tests

Recovery of U could be facilitated greatly if the spent U heel were separated from the Cu backplate by remelting the braze and allowing the Cu to fall away. This idea was stimulated by a single successful test of melt separation brazed with Gapasil at OR[53]. An 11 1/2-inch by 6-inch plate, was suspended horizontally in a vacuum furnace by resting the U ends on bricks, after machining away some of the Cu. At 900°C, the plate sagged and the Cu peeled from the underside and fell away.

Subsequent separation tests at RFP were unsuccessful on about a half-dozen coupons brazed with all four braze alloys[51]. In these tests, plates were suspended vertically from one side in a tube furnace with flowing inert gas. Slight shear movement was noticed in one instance. The uranium had to be coated with a protective glazing agent to prevent oxidation. Subsequent examination suggested that the U was oxidizing in the interface. The presence of solid oxides may have interfered with the lubricity needed to separate these tests appear to be inconclusive. However, it was felt that some sort of wedge or deformation was required at the melt temperature to break the wet surfaces apart and allow the weight of one plate component to fall. The idea of melt separation needs further evaluation.

V-2.5 Brazing Technique

V-2.5.1 The Reference Process

The OR-TRW brazing process was taken as the reference process for the FIDF. As-cast U in truncated pie-shaped segments was substituted for wrought and machined uranium in square geometry[14,47]. It requires assembling electropolished Cu and U plates, interspersed with 2-inch-wide strips of 2-mil-thick Gapasil, into a massive, bolted steel fixture. Then a stainless steel gas bladder (part of the brazing assembly) is pressurized to 20 psi with argon to form fit local contours of the Cu, Gapasil and U surfaces. This 28-inch-square fixture, weighing about 800 lbs., is placed horizontally into a vertical vacuum furnace whose heating coil is about six feet in diameter. Thermocouples are rested on the fixture at several points to monitor temperature. The fixture is heated in vacuum to 900°C over about a six hour period, held two hours, and cooled over two days. Only one plate is brazed per run. This process worked the first time it was tried and provided acceptable source plates for several years.

The selection of a brazing technique at SR had two parallel approaches: Adapt the proven OR process and develop a new technique that offers considerably improved throughput, smaller equipment, and lower temperature brazing.

<u>Demonstration With As-Cast Uranium</u>

Four 11 1/2-square plates were made by the reference process to characterize the Gapasil braze bond and to demonstrate acceptable brazing of as-cast uranium surfaces, rather than machined surfaces[14,50,53]. The first plate for SRL was made using wrought and machined uranium. Various sized holes were punched into the Gapasil foil. Some were filled with mica discs to preserve the hole as a standard for calibration of the ultrasonic analyses. Subsequent analyses showed that the holes could not be used as a standard because they could not be found by ultrasonics. Either the mica dissolved into the Gapasil or the Gapasil flowed over the mica. Other holes were left empty to assess wetting and flow of Gapasil. The empty holes could not be located later by ultrasonics or destructive analysis implying good flow of Gapasil at 900°C. Two quadrants of this plate were saved for tests of melt separation but never tested. Serial metallography on a one-inch-wide strip across the middle of the plate characterized Gapasil braze and compared bond quality with that for as-cast plates. Metallographic characteristics were found to be the same as for as-cast uranium, described under "Brazing Alloys".

The second and third plates were a continuous and a segmented as-cast uranium plate sent to TRW for testing in a separator[48,54]. Ultrasonics showed these plates contained no more non-bonds than are typical in plates made from wrought/machined uranium. This good bonding was achieved even though the surfaces of the uranium plates had a 3/32-inch bow across the plate and local surface roughness from brush marks where the mold release had been applied. (These defects in the uranium surface were subsequently eliminated by improved mold preparation techniques.)

A fourth plate consisted of segments of as-cast plate to test how rough a surface could be tolerated. The depth of local defects in this plate exceeded the thickness of the braze foil, so extensive non-bonding was expected and, indeed, found by ultrasonics. Ultrasonic analysis imaged many of the brush marks, fistulas and depressions observed visually in the plate. Serial metallography was performed along a diagonal. The braze generally contained few non-bonds larger across than the 0.35-inch criteria computed for burnout (cf. V-2.6.1). Porosity was frequent and small, but, the metallurgical characteristics were the same as for the bond in a plate made with wrought/machined uranium.

All of the data documenting these four plates are contained in DPST-85-326[50]. The compilation includes dimensional data, photographs, radiographs of uranium before brazing, brazing run sheets, ultrasonic analyses, and metallographic analyses.

Fixture Design

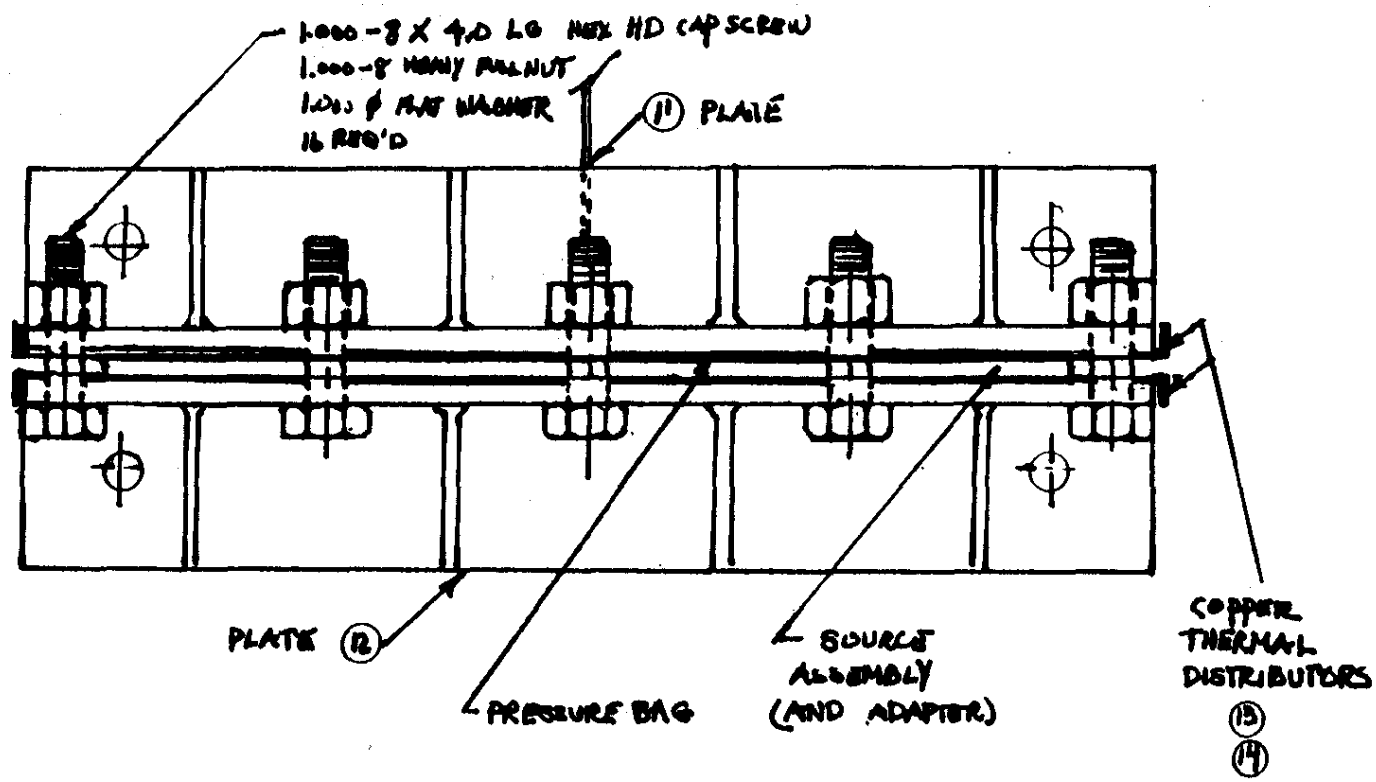
At the end of the program, SRL designed a replacement for the warped TRW fixture at OR, to be versatile and to accommodate at least two shaped segments per run in for the large vacuum furnace. The design could accommodate most shapes using adapters. One improvement was to increase stiffness. Simplified stress calculations and data from Faupel's "Engineering Design"[69] showed creep occurred continuously with use at 900°C in the TRW fixture. By converting fixture plate thickness from 1.75 inch to 0.75 inch and using light vertical stiffeners, the moment of inertia increased 238% while the weight decreased 33% from 756 lbs. By using tungsten carbide standoffs coated with parting ceramic, the plate and component alignment and fitup could be maintained through the furnace cycle. Figure V-4 through V-9 show an assembly and proposed inserts adapters for various configurations.

If successful, the intention was to stack plates two deep in a thicker insert for greater productivity.

Miscellaneous Tests

A few simple supporting tests[53] were done with the intent to improve the reference process. A double-thickness of braze, e.g., two layers of 2-mil-thick strips applied perpendicular to each other, did not eliminate the occasional small non-bond areas typically observed by ultrasonic analyses. Too much braze caused melt to ooze from the edge of the plates at different sites, necessitating some machining to remove.

An unsuccessful attempt was made to braze in a fixture without a steel bladder and, hence, no pressure, applied. Ultrasonic inspection showed this plate to be badly non-bonded. Another was brazed without the restraint of a bolted fixture, using the weight of the uranium for pressure. Ultrasonics showed this plate to be greater than 80% bonded, but not as well covered as when a uniform pressure is applied during brazing.



NOTES:

1. WELD 3/8" TH X 4" STIFFNERS TO PLATE, MACHINE FLAT, $\overset{32}{\nabla}$ RMS WITHIN 0.010, AFTER ANNEALING
2. BREAK ALL CORNERS .06 X 45°
3. ALL MAT'L 304 L S.S. OR EQUAL (ANNEALED)

FIGURE V-4. Brazing Fixture - Edge View

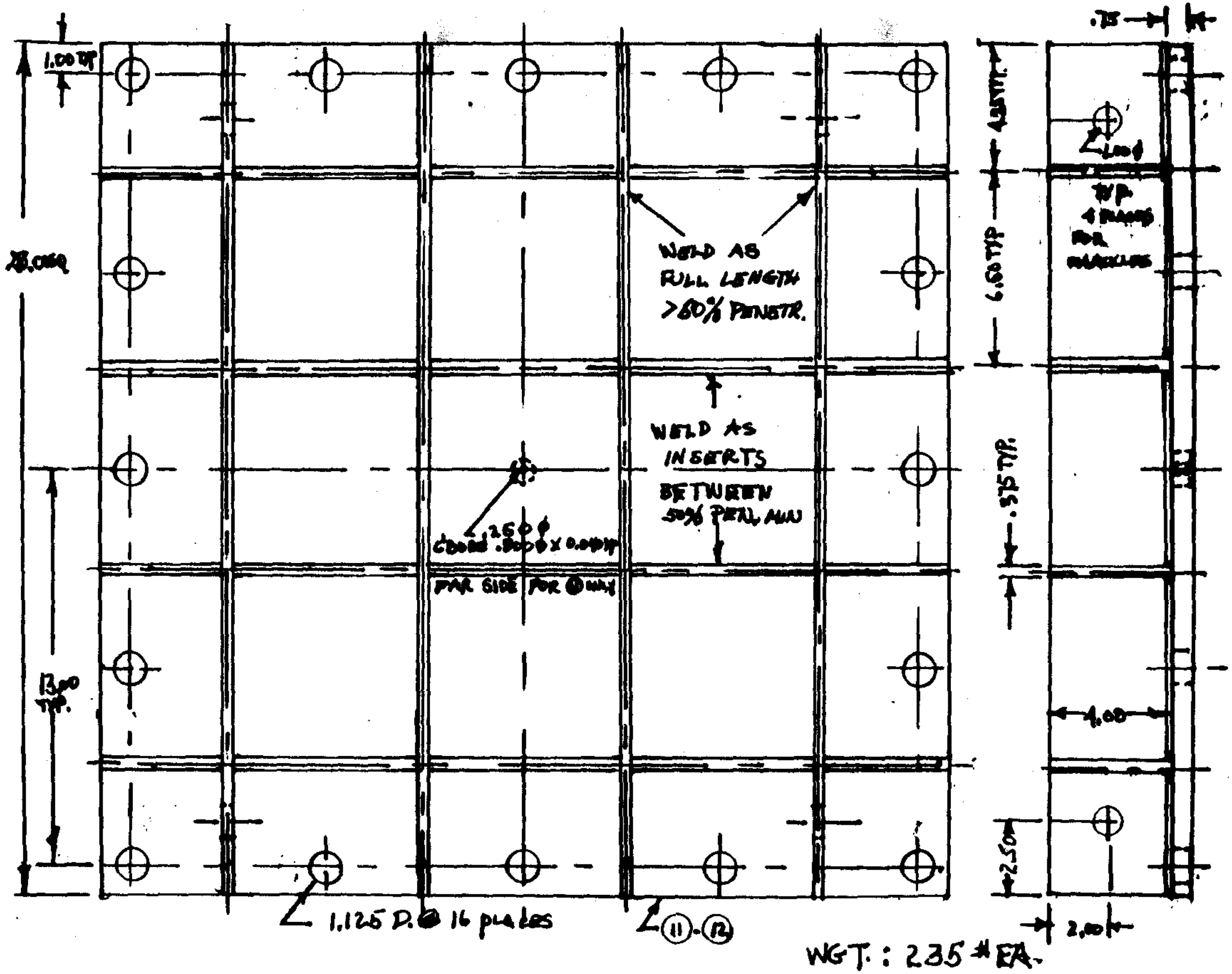


FIGURE V-5. Brazing Fixture - Source Plates

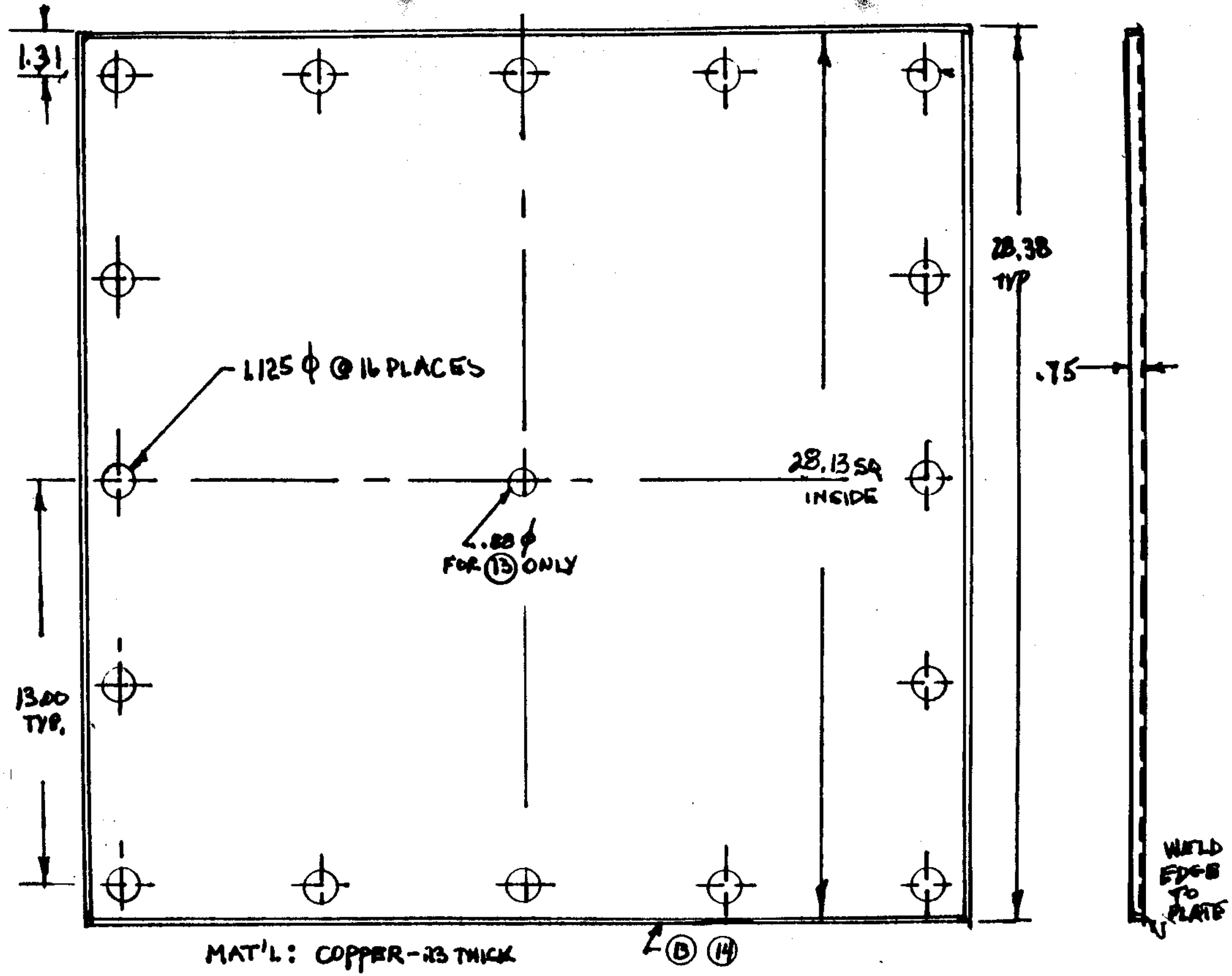


FIGURE V-6. Brazing Fixture - Thermal Distributor

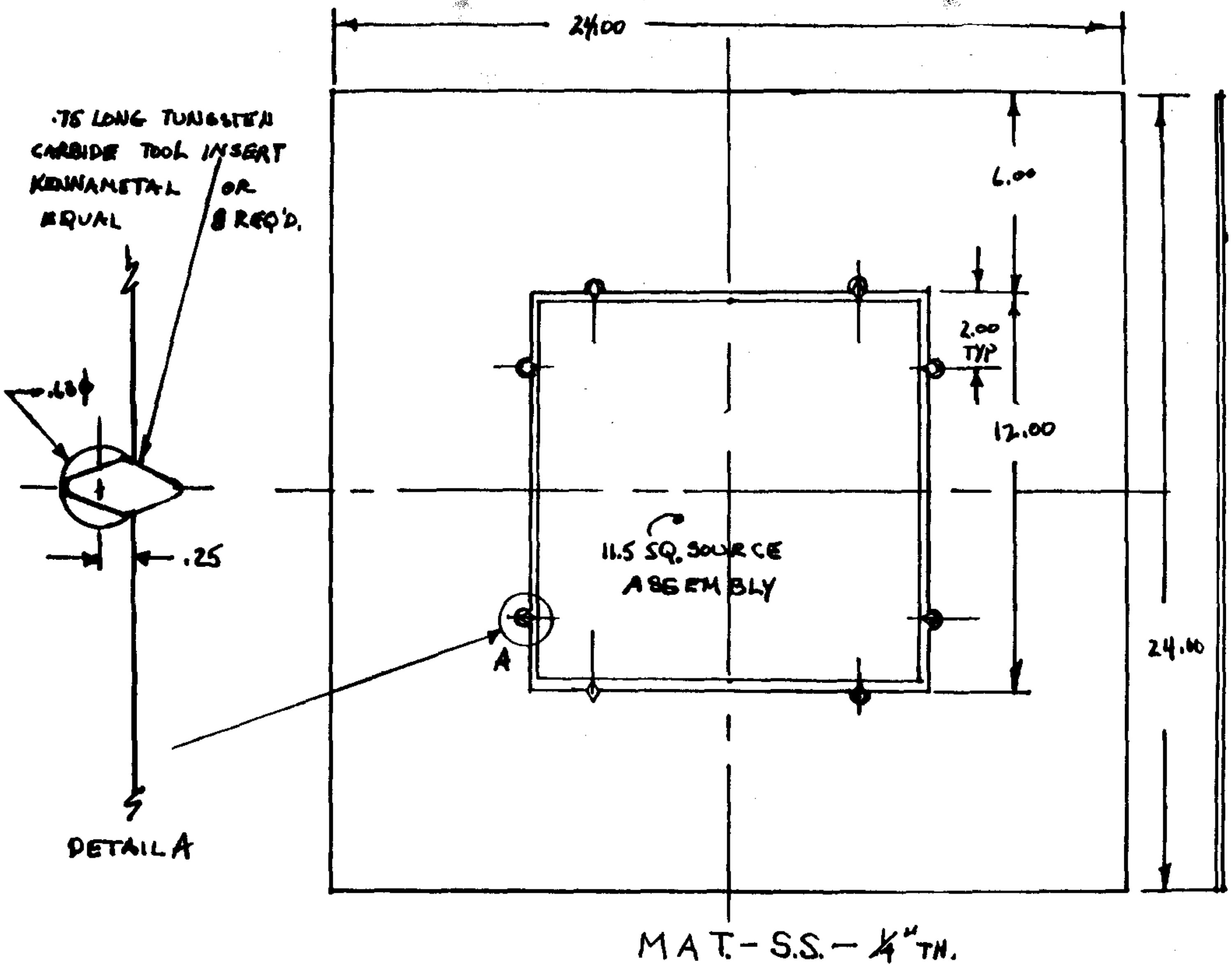


FIGURE V-7. Brazing Fixture - Adapter #1

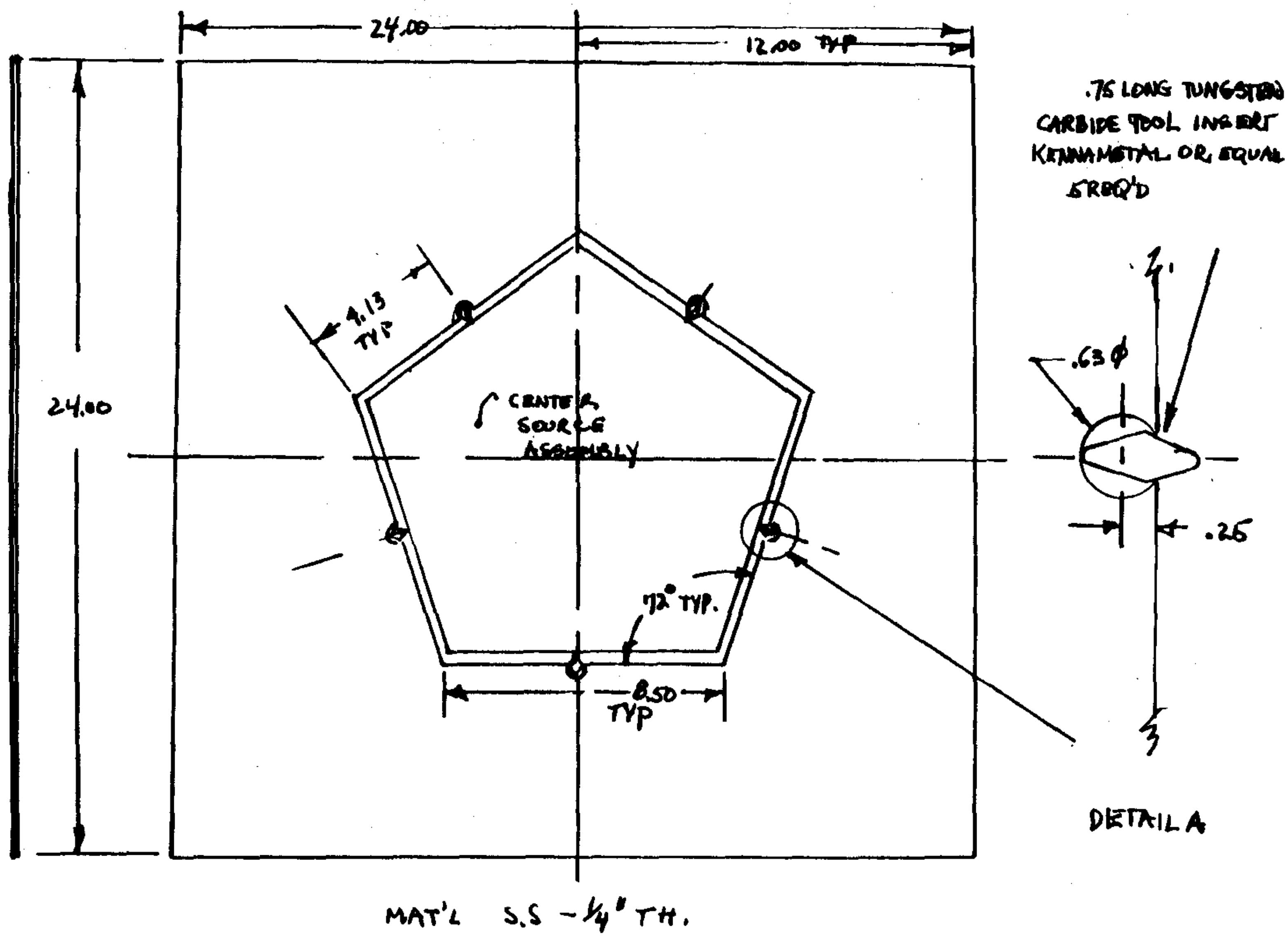


FIGURE V-8. Brazing Fixture - Adapter #2

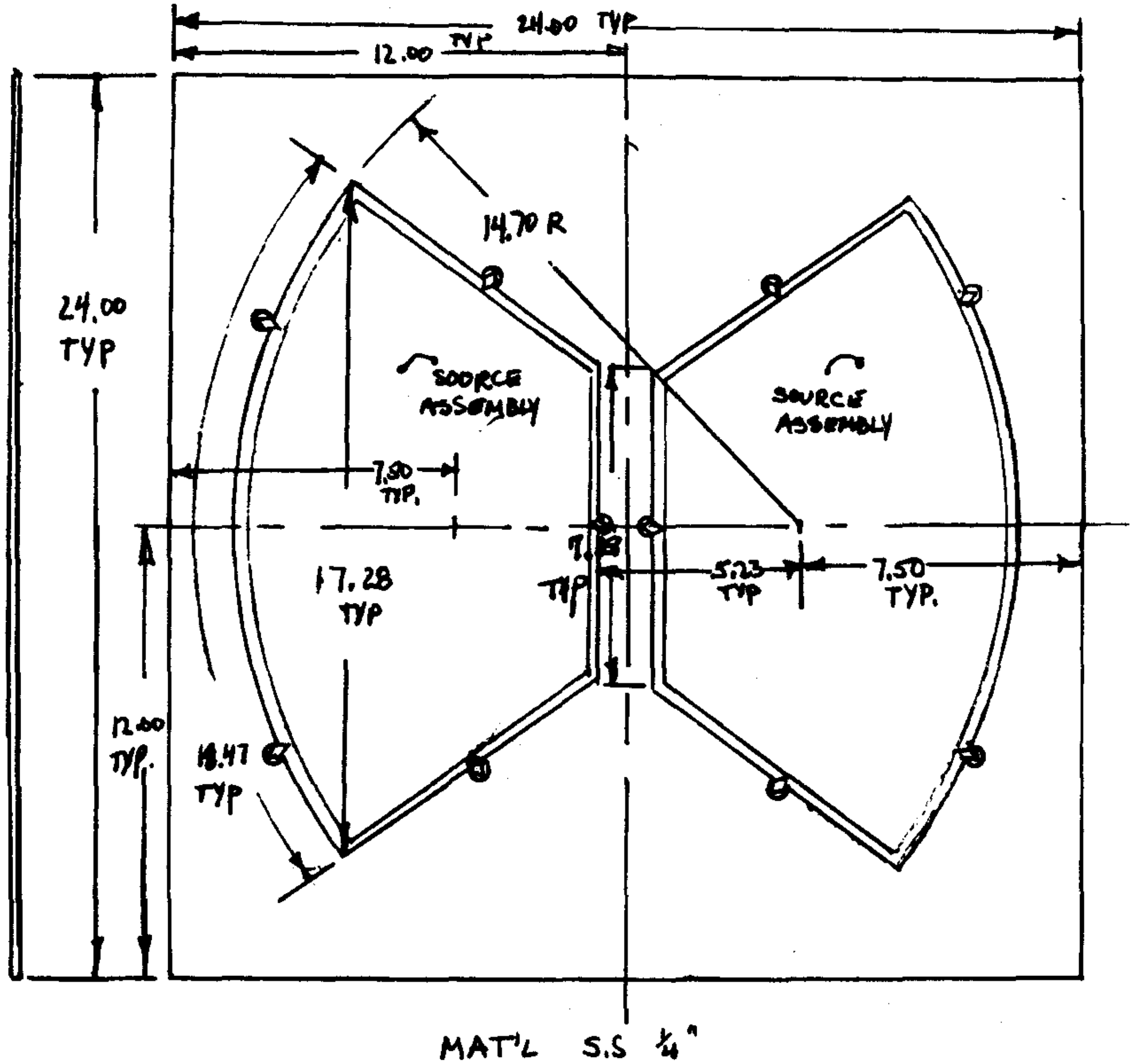


FIGURE V-9. Brazing Fixture Adapter

V-2.5.2 Alternative Bonding Processes

RFP tried vacuum hot pressing, hot isostatic pressurization (HIPping), cast bonding, brazing in a vacuum hot press and induction-heating pressure-bonding (IHPB)[51,52]. Vacuum hot-pressing, HIPping and brazing in a vacuum hot press were successfully demonstrated. Cast bonding of U onto Cu did not work. However, the bonding process with the most attractive potential appears to be IHPB. The program was terminated before this technique could be tried on Cu-U plate.

Vacuum Hot-Pressing

Vacuum hot-pressing involves solid state diffusion bonding of Cu-U without any intermediate bonding material[43,52]. Cu and U ingots of preselected thickness are hot-pressed at 825°C under 850 psi for 3 to 4 hrs. The resulting four-inch- thick ingot is forged thin enough to be rolled. Repeated rolling at 850°C produces a final plate of the desired thickness for both Cu and U; but, the segment must be machined from the rolled plate. Rolling temperatures and reductions are critical to match the relative deformation of Cu and U and to mitigate the effect of the brittle Cu_5U phase on shear strength of the bond.

This technique produces plate with excellent bonds, e.g., no porosity or cracks and shear strengths up to 80,000 psi. However, forging, rolling and machining are operations that would be difficult and expensive to do in FIDF, so other techniques were explored.

Hot Isostatic Pressurization

HIPping offers advantages of a crack-free, solid-state bond, no limiting temperature gradients, high throughput (several segments at once, and low thermal inertia because of the absence of platens and fixtures), and the application of pressure locally to accommodate surface fitup[43,52]. However, the HIPping pressures should be below 2000 psi to lower the cost of the furnace and to provide improved safety margins.

RFP obtained excellent bonds in three tests at 15,000 psi, 725°C, and two hours using Ni foil. The samples were sealed in a thin-walled stainless steel can[44] under vacuum and welded using a TIG welder. (Crimp seals in steel bags should do as well.) Copper and ceramic standoffs were used to prevent steel from alloying with the sample. Tests at 1000 and 10,000 psi are planned.

Induction-Heating Pressure-Bonding

Investigating IHPB had the same purposes as investigating lower melting temperature brazes, to conserve energy, to accelerate processing, and to reduce cooling costs within fabrication enclosures. Induction heating with water-cooled coils imbedded in a dielectric platen, has the potential to heat a braze assembly in minutes. If that platen were combined with an operating press, textured, as-cast U would have the required intimacy with the braze for bonding, and, cooling would be faster than radiative emission alone. Also, pressure relief during cooling might alleviate edge bond cracking.

Much of the information on induction heating presented here was obtained in a visit to a vendor with RFP personnel. Commercial presses routinely braze (in air) copper or aluminum bottoms to stainless steel cookware and are available from Radyne/AKO, Milwaukee, WI. Four of their systems are in constant operation, two located at the Eckoware Plant in Maisland, OH that could be visited by arrangement. According to Radyne personnel, a single head of their existing design, Figure V-10, could be adapted for vacuum operation. Large diameter, welded bellows were to be used for chamber halves to enclose the rams and platens. External reinforcement with vertical slide rods would prevent bellows collapse during evacuation. The press capacity is more than adequate for PSP sourceplates, about 105 square-inches of heated platen area at up to 100 psig pressure. Pressure during fixture brazing at OR with an inflatable bag is 20 psig. However, other equipment parameters have to be determined before procuring a press for process development. They are: 1) operating frequency and required power supply, and 2) the coil design for most uniform heat generation.

Radyne personnel compared their accumulated data for the SRL material system and stated that austenitic stainless steel was a poorer heating case of U. They felt it would be a satisfactory substitute for developing IHPB, after RFP completed scheduled parametric test work with an experimental coil procured from them. Radyne data follows:

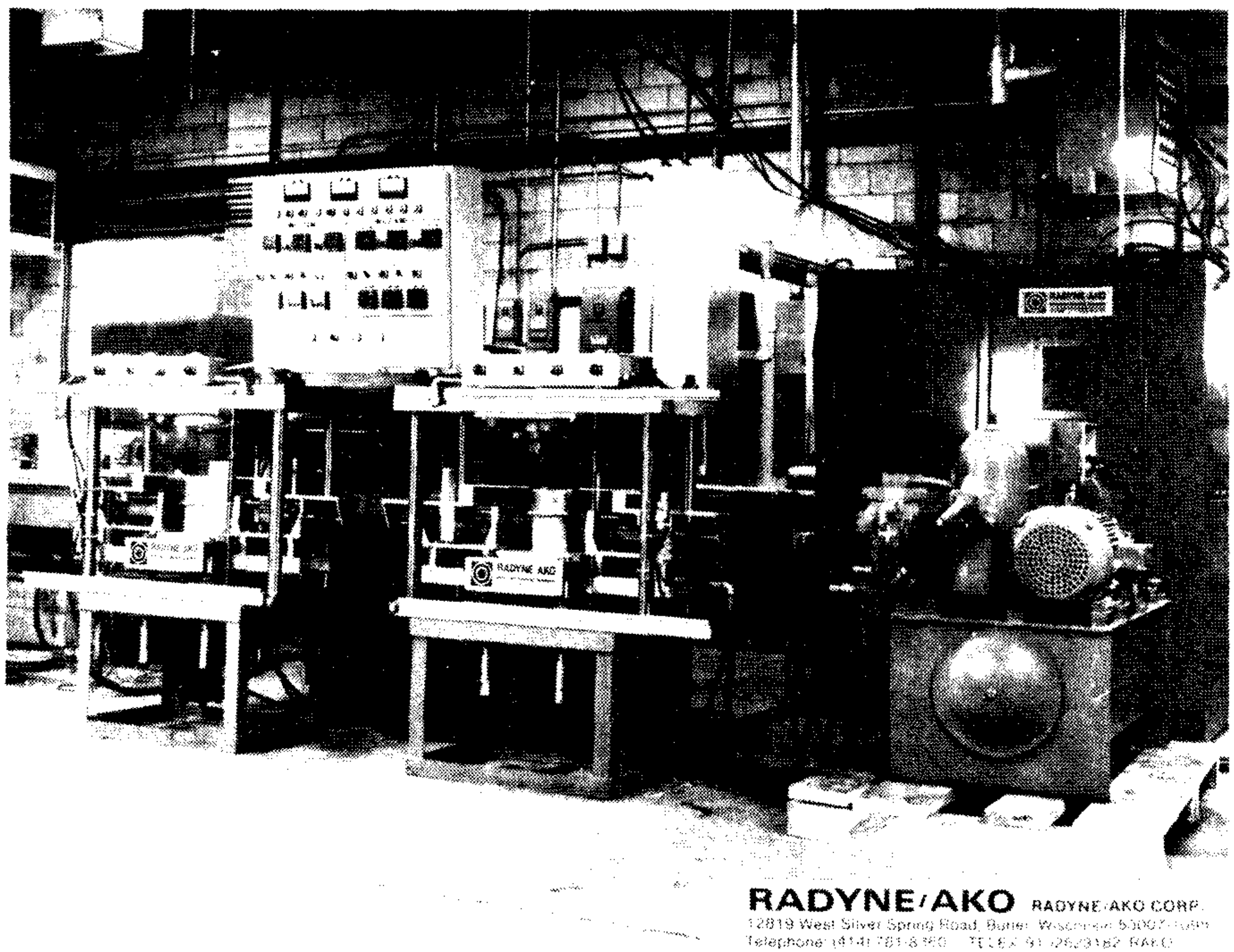


FIGURE V-10. Radyne Installation

RESISTIVITY MICRO-OHM INCH	THERMAL COND. btu/in^2,°F, SEC.	SPECIFIC HEAT btu/lb., °F
Uranium (U)		
Alpha (270°C) 11.8	0.064	0.028
Beta (727°C) 22.0		
Gamma (827°C) 21.3		
Stainless Steel (SS) - Type 304		
12.6	0.045	0.120
Copper (Cu)		
0.66	0.918	0.092

Radyne agreed to contractual development work for SRL, if it led to procurement of a press. Limited uranium use did not bother them, if it were approved by local and Wisconsin authorities. They had developed a forge-shaping heating system for a customer making U penetrator shells before regulations became restrictive.

Essential components for a development system located at either SRL or at RFP are as follows:

Component	Unit Cost-K$	Dimension-In.
120 kW-TR 10 (10 kHz) Power Supply	43.0	59"WX38"DpX76"H
Taps	3.5	(In above)
Heating Station	5.0	22"SqX34"H
Bus Bar	1.0	
Recirculating Cooler	6.0	48"WX43"DpX36"H
Single Press (Table) and Hydraulics	40.0	48"WX24"DpX80"H
Without Vacuum System and Bellows (Chamber)	About $100.0	

This price does not include major system redesign, which they believe is not necessary.

Induction Heating Experiment at Rocky Flats

RFP's immediately available equipment limited work to 1/3 scale and use of a radio-frequency (180 kHz), 5 kW power supply. RFP decided to try the Radyne coil in an existing facility, a vacuum chamber mounted on a tensile test machine.

RFP expected to use 1/8-inch thick U and, with tests, determine if increased time of heating could offset this power deficiency.

The Radyne coil consisted of two separate half coils arranged so that circulating currents would not interfere with each other's path. Interconnections were made as tube jumpers beneath the path and in a less-than-critical, planar distance, see Figure V-11. Spaces between tubing were solid transite for support when pressing and to prevent crushing the Cu tubing. Sauereisen #8 cement, a ceramic, sealed the entire platen and its rated compressive strength was 250 psi at 400°C. Radyne personnel would not predict many conditions for the four-inch-square, coil, because of its hybrid design; however, their estimate of depth of heating in the U was:

DEPTH OF HEATING - IN.	FREQUENCY - kHz
0.217	10
0.1380	25
0.0320	450

Initial tests[51] were thwarted by water leakage; however, a 4-inch X 4-inch X 3/8-inch thick plate of U laid atop a graphite susceptor was heated to 390°C in 6 seconds before arcing. When the coil was delivered, silicone sealant had been applied to groove ends of the transite platen for retention of the ceramic paste during curing. RFP refired the assembly to disintegrate the silicone rubber and caused a leak by firing at a temperature just above the brazing temperature used for coolant tube junctures. Attempts to use a molecular water sealant failed; the replacement coil arrived near the end of the program. A 10 kHz-15 kW power supply, retrieved from storage, arrived, but, could not be installed in time.

Induction Heating Experiment at Oak Ridge

OR personnel demonstrated basic induction heating feasibility in air with their lab equipment[53]. A square coil was wound from 3/8-inch O.D. Cu tubing with four secondary coils wound at the corners. Secondary turns increased flux density where heat losses were the greatest. It was suspended 1/8-inch above an 11.5-inch square X 1/2-inch thick plate of stainless steel. Components were separated by sheet mica. Power from a 10.08 kHz-15 kW Tocco induction unit raised the plate temperature to a glowing red in eight minutes. Plate temperature reached an estimated 1000°C and appeared fairly uniform a few seconds after shutting off the power. The

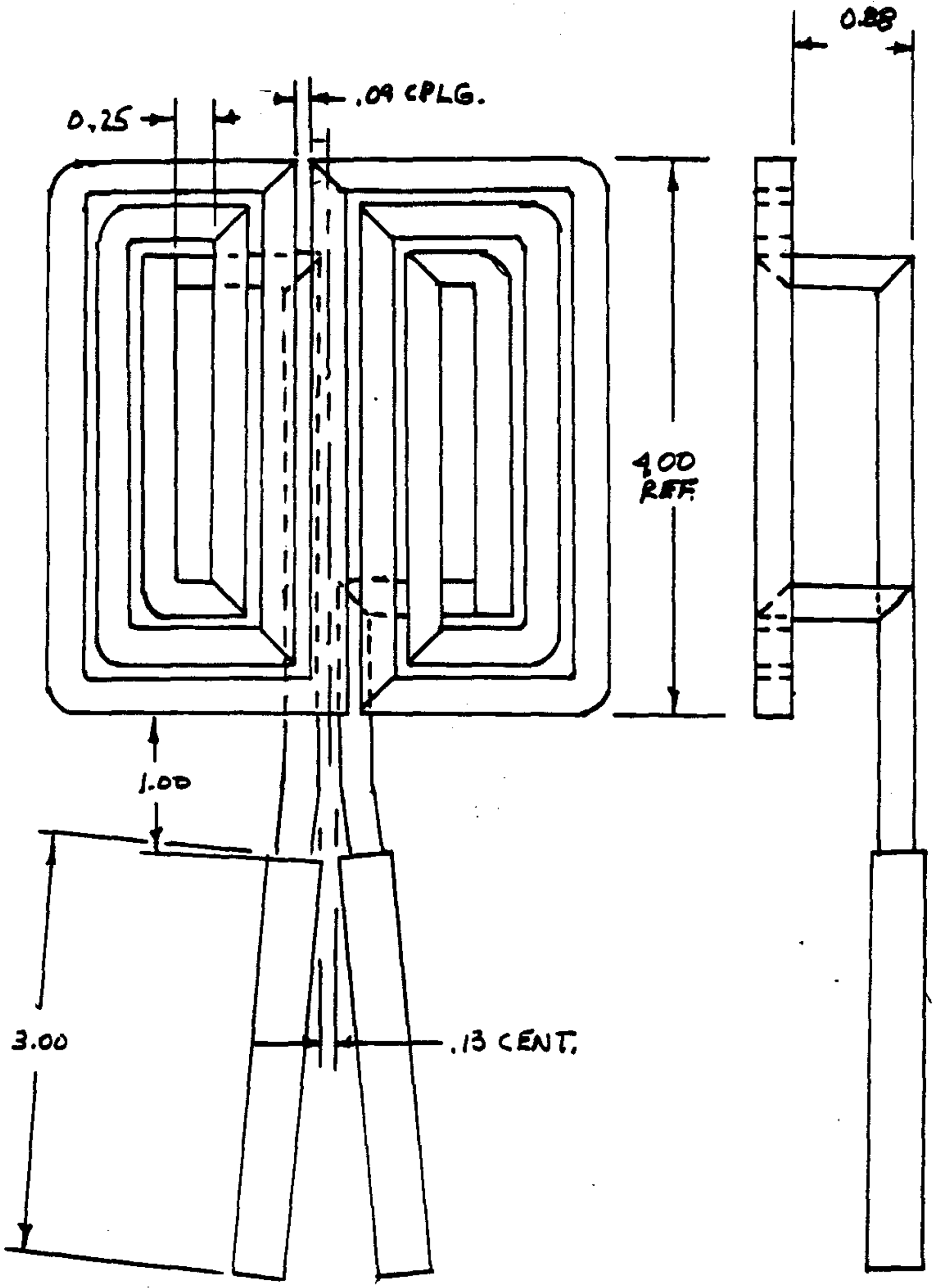


FIGURE V-11. Radyne Induction Heating Half-Coils experiment was repeated for SRL during the program termination visit. Graphite support blocks for the plate were used in place of ceramic ones. The support area temperature lagged due to the increased conductivity of the blocks and had just begun to glow when a thermocouple between supports registered 900°C.

Years before, OR had successfully induction-heated, in vacuum, U sections to these temperatures for another customer.

Brazing at Savannah River Laboratory

The IHPB technique, together with conventional vacuum brazing ovens, were to be installed in a new facility at SRL referred to as "Source Assembly Fabrication Facility". About half of the "Hot" shop (U machining facility) of Bldg. 773-A was to be stripped of large lathes and other unused equipment. The facility's goals were to demonstrate a capability to fabricate full-scale segments, cast at RFP, and to develop appropriate procedures.

A project had been written for procurement and installation of the following equipment in the available 1400 square feet of area:

1. A Radyne IHPB press with ancillary equipment.
2. A vacuum resistance heating furnace, 6-foot-dia., Abar Mfg. or equal
3. An oxidizing furnace with removable liner and controlled atmosphere gas supply
4. A dry, wire-brushing station for abrading plate oxide film and appropriate filtration and fire protection
5. A vented chemical hood with sinks for collection of electropolish solution and DC power supply
6. A dry, abrasive, blast cabinet with appropriate filtration and fire protection
7. A portable lift for handling heavy components to the furnaces
8. Appropriate fixtures and storage area
9. Work tables and storage cabinetry
10. Ultrasonic analysis equipment

V-2.6 TESTING OF PLATES

V-2.6.1 Burnout

The largest non-bond in the braze that can be accommodated in FIDF operation was computed by TRW based on a plasma flux of 100 w/cm^2 on the face of the source plate and a copper backing maintained at 100°C[55]. These calculations indicate that half or more of the area of the plate can be non-bonded, provided no single area (or elements of contiguous areas) exceeds the area of an ellipse with a major axis of 1-inch and a minor axis of 0.35-inch. This computation has led to a working specification for unacceptable non-bonds as areas greater than 0.150-inch across for the development of an ultrasonic technique.

These computations should be refined for the actual conditions in the FIDF. Power levels are less than originally specified, and heat transfer conditions are somewhat different. In any case, tolerable non-bonds are expected to be greater than 0.35-inch across, which should be routinely achievable and detectable during production of source plates in FIDF.

V-2.6.2 Ultrasonic Testing

Ultrasonic scanning has been developed as a non-destructive quality control technique[56]. Flat-bottom holes of different sizes were drilled through the U to the braze and used as standards to establish the conditions for ultrasonic reflection through the Cu. The technique readily detects non-bonds down to 1/16-inch. Variations in the metallurgical condition of the copper were shown to affect the calibration sufficiently to require a standard that is made from a plate fabricated by the actual production process.

This technique was applied to full-sized plates made at OR both with wrought-machined U and with as-cast U. Over 95% of the area of these plates was shown to have acceptably small non-bonds when required brazing conditions were adhered to.

The non-bond areas that were detected ultrasonically were correlated with three types of defects observed visually in the braze layer of several peeled areas of a Gapasil brazed plate. Peripheral cracks were observed intermittently around the edge of the plate. Gaps between strips of Gapasil foil were detected. And random blisters were observed that may be related to inadequate cleaning of the Cu or U surfaces before brazing.

Thermographic analyses may be another non-destructive technique to assess non-bonds. This type of analysis has the advantage of being related to actual heat transfer performance of the plates and does not require immersion in water, which can be both a criticality threat and a handling inconvenience in containment.

V-2.6.3 Response to Plasmas

One of the principal objectives in the development of fabrication processes was to obtain early assurance that as-cast and segmented plates would withstand both the thermal stresses in a separator and sustained sputtering. Extensive preparations were made to test these in the half-scale M2B separator at TRW[48,54]. Two 11 1/2-inch-square plates were cut in four segments which were then brazed with Gapasil at OR using as-cast material from RFP. One U plate was cut in four segments which were then brazed to a Cu backplate with spaces between the U quarters varied from near contact to about 110 mils. These plates were completely characterized[50] and sent to TRW.

The continuous plate was to have been exposed in the separator at about 50 w/cm^2 for long enough to saturate thermal stresses[54]. The segmented plate was to have been exposed long enough to remove about 75% of the uranium. Collection tabs were to be mounted in the separator to detect sputtering of braze metal or copper from the bottom of the gaps between segments. Any burnout in the source plate was to stop the test. Both plates were to be returned to OR for destructive assessment of burnout areas, cracks, bowing, erosion profiles, preferential sputtering of large oriented grains, and the tolerable aspect ratio of the gaps between segments.

These tests were limited to a power level less than planned for FIDF. Consequently, lower thermal stresses and more burnout tolerance would be realized than are ultimately required. However, a successful performance of the plates under these conditions would provide confidence in the ultimate efficacy of the reference process. No plates had heretofore been subjected to these power levels, over so large an area for so long an exposure. The separator tests were not started because the program was cancelled.

V-2.6.4 Burnout Tests

An experimental verification of braze quality was needed together with a determination of the tolerable non-bond areas in plates fabricated by any development process. Consequently, a burnout heat flux facility was designed. Eleven and one-half-inch round plates were to be radiantly heated on the U face and water-cooled on the Cu side at known temperatures and heat fluxes. Plates with known non-bond areas and locations could be intentionally burned out at known fluxes to provide a specification for tolerable cracks and pores in the brazed or soldered interfaces. This facility was designed but not built.

V-2.7 Brazing Status

The following are the significant accomplishments to date:

- Surfaces of 11 1/2-inch-square as-cast plates are sufficiently flat and smooth that brazing produces source plates with the same non-bond quality as those brazed with wrought-machined uranium. This is assurance that as-cast segments can be used without machining the brazing and exposure surfaces.
- Thermal analyses show that an appreciable area of non-bond can be tolerated in the braze provided no single non-bond exceeds that of an ellipse 0.35-inch by 1.0-inch. This is the burnout criterion for bond quality.
- An ultrasonic technique has been developed capable of locating and measuring the area of non-bonds in the brazed source plates. This technique can be used as a quality control device for production.
- Small-scale brazing tests at RFP and metallurgical inspection of full-scale plates brazed at OR with Gapasil alloy have identified four braze alloys that appear to be suitable to braze Cu to U. They are silver-based and silver-copper-based alloys and pure nickel ranging in brazing temperatures from 900°C down to 718°C.
- Induction-heated pressure-bonding (IPHB) with flat coils has been identified as the most attractive technique to braze full-sized segments to accomplish high throughput in containment. Diffusion bonding below melting has also been demonstrated by hot isostatic pressing and by hot-pressing ingots followed by forging and rolling into plate.

Both segmented and continuous source plates using as-cast uranium have been brazed with the OR Gapasil process and delivered to TRW for plasma tests in the M2B separator. The separator tests have not been done. A design for an improved fixture for the OR process has been developed but the fixture has not been constructed or tested.

About 50 small-scale test brazings of as-cast U have been done using Ni, Cusiltin-10, Cusil, and Gapasil-9 braze alloys[51]. These screening tests have shown the general requirements for melting, braze thickness and pressure. A chronic cracking problem persistently recurs in the braze alloy in these tests. Yet bond strengths appear to be adequate. A statistically designed series of small-scale parametric tests have been initiated to develop the correlations of time, pressure, temperature, surface condition, and braze thickness with metallurgical features for nickel braze[51].

Small-scale, hot isostatic pressing (HIP) tests are underway to determine if applied pressures less than 2000 psi can accomplish bonding with nickel. Pressures below 2000 psi lower the cost of HIPping equipment substantially.

A small-scale test of induction-heating pressure-bonding (IHPB) is underway to show the feasibility of brazing plates with a flat coil design imbedded in dielectric press platens. Radyne/AKO, Inc., has been identified as a supplier of full-scale IHPB equipment (cookware presses).

Small-scale tests of melt separation of Cu and U by remelting the braze layer have shown the need for mechanical assistance and oxygen-free atmospheres to effect separation. These tests were stopped pending design of such equipment.

A facility to accomplish burnout heat flux tests on 12-inch diameter plates was designed but not constructed.

V-2.8 Recommendations

Should the uranium-236 separation program be restarted, the following recommendations are made to complete the fabrication development. Both continuous and segmented source plates made from as-cast uranium need to be tested in a plasma at high power density to assure that thermal stresses can be accommodated. Also, a demonstration is necessary to show that typical small non-bonds below the calculated size do not cause burnout, and that erosion of uranium proceeds uniformly for the larger non-random grain orientations inherent in cast uranium. Sufficient uranium should be sputtered from the segmented plate to assure that typical aspect ratios of the slots between segments are acceptable after enough U has been removed to threaten the sputtering of the Cu backplate.

Thermal analyses of the source plate ought to be recomputed for the burnout heat flux and conditions planned for FIDF to specify the size of tolerable non-bonds. Thermal analyses are also needed to analyze shear stress and to help explain the peripheral and intermittent cracks appearing in brazed segments. Full-sized segments should be tested in a burnout heat flux test facility to establish experimentally the correlation between size and location of non-bond and burnout fluxes and to assure the mechanical performance of source plates.

Because the present OR brazing technique is the reference process, the redesigned fixture used to hold and pressurize the Cu and U plates during brazing ought to be built and tested. The fixture has the ability to "gang braze" a few plates at once and be recycled every hour instead of four days as presently required. Temperature-time gradients should be decreased by removing mass from the fixture and incorporating Cu for improved heat transfer.

The selection and assessment of braze alloys should continue emphasizing Cusiltin-10, nickel, and a custom alloy such as 80 Ag-10 Sn-10 Ga to lower braze temperature to 650-700°C and promote bonding. Parametric tests should be done with the best candidates to provide a design basis for the brazing equipment, e.g. time, temperature, pressure, temperature gradients. These parameters together with braze thicknesses, and surface condition must be specified for the following reasons: (1) to maximize wetting and bonding, (2) to minimize formation of brittle phases, (3) to minimize diffusion of braze constituents into Cu or U plates, (4) to preserve original braze compositions, and, (5) to facilitate subsequent melt separation of spent plates.

Ultrasonic techniques to assess non-bonds will need to be calibrated for the particular brazing process used. Differences in the metallurgical condition of the copper through which the sound wave is pulsed can cause errors equivalent to tenths-of-an-inch in size of non-bonds.

Creep tests should be run to assure that the segments will not move down the vertical source plate in 30 hrs. at peak heat flux.

The cause and extent of peripheral cracks and intermittent cracks observed in small-scale braze tests need to be assessed. Persistent peripheral cracks in the outer 0.25-inch of brazed segments may be caused by stress relief from differential shrinkage on cooling while physically restrained. If so, segments would require machining to prevent edge burnout in the separator. A more ductile braze alloy may relieve this problem. Intermittent small cracks within a segment may be tolerable because high bond strengths are not required to support the plate; and considerable non-bond area is tolerable before burnout, if the non-bonds are sufficiently small.

The development of melt separation should continue because melt separation of spent plates is much simpler than machining off Cu from U. Mechanical assistance appears to be required to force separation with a reliquified braze layer. A bending load or a chisel edge pushed into the edge to start separation should be sufficient.

HIPping tests at loads below 2000 psi should be completed. Solid state bonds made at 15,000 psi were excellent, e.g., no cracks, complete bonding, high strength, good alloy definition for subsequent melt separation, and no preferential loss of braze constituents. HIPping offers the best control of temperature, time, and ΔT because massive fixtures and press platens are not required. Several segments can be brazed at once. But HIPping equipment is only economical at pressures of 2000 psi and below.

The concept of induction-heating pressure-bonding (IHPB) needs to be demonstrated and full-scale equipment developed. Flat induction coils imbedded in a non-reacting dielectric press platen must control temperatures uniformly throughout the segment being brazed. The equipment must be developed to full scale for containment in FIDF.

For either the IHPB or HIPping techniques, many full-sized segments must be brazed to optimize design and establish operating limits. Further, for any process, plates should be tested in CTM or the FIDF at full power density and for full cycles to demonstrate performance.

V-3 MODULE COOLING

V-3.1 Heavy Water Cooling

The use of fluorocarbon coolant for the FIDF separator module internal components involves some difficult problems. A preliminary study(57) was made of the possible use of heavy water as coolant in the FIDF. The use of 100 liter of heavy water was estimated to be acceptable from criticality considerations. The four coolant systems serving the module internal components were designed to have a total coolant volume of 100 liter. A summary is given in the following table:

MODULE COOLANT SYSTEMS

System	Power, kW	Volume Liter	Volume gal	Flow, gpm	Pressure Drop psi
Source	492	35	9.2	93	51
Drive Coil	443	49	13.0	84	100
Collector	71	11	2.9	14	10
Wave Guide	14	5	1.2	3	36
TOTAL	1040	100	26.4		

The maximum assumed flow was 20 ft/sec. with a maximum temperature differential of 20°C. Further design and experimental verification is required if the program is continued.

V-3.2 FLUOROCARBON DECOMPOSITION AND REACTION WITH URANIUM

Large heat loads on various internal components in the Plasma Separation Process (PSP) module make cooling by an external fluid mandatory. The ideal coolant must possess good heat transfer characteristics, low corrosivity and conductivity, and adequate thermal stability. Deionized water, when treated by ion exchange, displays these properties and could be used as a coolant for separation of non-fissile materials. For the mission of uranium oralloy upgrade, however, the presence of large amounts of U-235 in the process vessel introduces the potential for a criticality in the event of a leak in the water cooling system.

A fluorocarbon marketed by 3M Corporation under the name Fluorinert FC-75 (a mixture of C_8F_{18} and cyclo - $C_8F_{16}O$) was proposed as an alternate coolant since its non-hydrogenous nature would permit critically safe operation of the PSP module.

Laboratory scale studies were undertaken at SRL to determine the effect of temperature on FC-75 and to monitor the rate of uranium/FC-75 reaction. A small vacuum line designated the Fluorocarbon-Uranium Reactivity (FUR) apparatus was constructed in F-055. In general, the rate of decomposition and/or reaction was monitored via pressure and temperature changes. Further details were obtained by analysis of residual gases by infrared spectroscopy and gas chromatography. In the fluorocarbon-uranium reaction studies, residual solids were analyzed by X-ray diffraction.

The thermal stability of FC-75 was ascertained during 30 pyrolytic experiments at temperatures between 200 and 700°C[58]. Noticeable decomposition of FC-75 occurred at 400°C, but decomposition rates were greatly accelerated at higher temperatures. At 700°C, pressure increased at an initial rate greater than 4%/second and doubled in less than 10 minutes. At all temperatures, pressure continued to rise indefinitely with time. The kinetics of this decomposition appeared complex since no simple functionality could be found to adequately fit the data.

Infrared spectroscopy and gas chromatography permitted identification of several gaseous decomposition products, including CO_2, hexafluoropropylene (C_3F_6), and perfluoroisobutylene (PFIB, C_4F_8). At least two other decomposition products were present but could not be unambiguously identified. The toxicity of hexafluoropropylene and PFIB coupled with their rapid rate of production suggests that the risk involved with fluorocarbon cooling is unacceptably high. PFIB levels 3-4 orders of magnitude above the LC50 value for this material (17 ppm for a 10 minute exposure) would be attained from an accidental spill of 100 liters of fluorocarbon inside the PSP vacuum module. The pressure rise due to FC-75 vaporation and decomposition alone would not be rapid enough to endanger the integrity of the vacuum chamber; the total pressure from a 10 second, 100 liter spill is estimated to be 2 atmospheres. The toxic by-products would therefore be confined to the vacuum module and the off-gas treatment system.

These toxicity dangers would be greatly amplified if the fluorocarbon-uranium reaction were sufficiently rapid and exothermic that a pressure shock wave could be generated. Rupture of the process vessel would expose personnel to the dual hazards of missiles and toxic gases.

The reaction of bulk uranium and powdered uranium with FC-75 was investigated at temperatures between 200 and 700°C[59]. The pressure of the gas and the temperature of the uranium were monitored as a function of time. The changes in pressure were quite similar to those observed from FC-75 decomposition. This similarity resulted primarily due to rapid termination of the fluorocarbon-uranium reaction via formation of a protective fluoride skin on the uranium surface.

Temperature monitoring indicated modest temperature changes of 50-100°C for the bulk uranium/fluorocarbon reaction. Much larger changes were noted for the reaction of high surface area uranium powder and FC-75. With an initial powder temperature of 200°C, the temperature soared approximately 1000°C in one second. Given the large amount of uranium powder which will be deposited on the shrouds and drive liner in the PSP module, the potential for shock wave generation by the rapid deposition of a fraction of this exothermicity into the gas phase appears high. Careful measurement of the heat of reaction of uranium and FC-75 is needed before the magnitude of this pressure pulse can be calculated.

Analysis of the residual products from this reaction indicate that UF_6 is not produced. Production of UF_6, a volatile radioactive species, would introduce yet another serious hazard. Infrared analysis of the residual gas mixture from these fluorocarbon-uranium reactions revealed the same toxic products that were formed from FC-75 decomposition alone. At low temperatures (200°C) where FC-75 decomposition is undetectable, no UF_6 was observed even though a violent reaction occurred between FC-75 and uranium. Analysis of the residual solids by X-ray diffraction indicated that UF_4 and UO_2 were the primary components; much of the UO_2 was undoubtedly formed by oxidation when the powders were removed from the furnace.

Further study is needed to determine the full impact of the fluorocarbon-uranium reaction. The results of this study indicate that the possibility of module overpressurization and rupture with concomitant toxic gas release cannot be regarded lightly.

V-4. COIL LINER

A liner is required to protect the coil from uranium deposition as the ions travel from the source plate to the collector. Operating temperatures for the liner are estimated to be less than 1000°C, therefore, the uranium will be collected as a solid and chemical compatibility is not a major concern in the selection of materials. The liner material should be non-conductive and have a low dielectric loss. The liner should also have a lifetime of at least 10 cycles and should be lightweight to simplify the refurbishment operation. The liner will be subjected to thermal stresses from cycling between 25°C and 1000°C and from a non-uniform temperature distribution during operation.

Using the above criteria as a basis for materials selection, a ceramic material marketed under the tradename Udicell was selected as the primary candidate. Udicell is a highly porous, continuous, open-cell material. This sponge-like structure results in desirable properties such as very low density, low heat capacity, and excellent thermal shock resistance. Evacuation of the interior of the liner could be accomplished by pumping through the Udicell. Also, a liner constructed of Udicell would have much less surface area and, therefore, less outgassing, than one made with fiber based materials. The most important advantage of Udicell may be that the uranium would deposit throughout the structure rather than forming a continuous conductive film as it would on a solid surface. Therefore, the rate of increase in conductivity and dielectric loss as uranium is deposited will be minimized with Udicell.

In the initial phase of the liner development the specifications for Udicell were established. The following specifications were selected:

Composition:	90% Al_2O_3
Structure:	30 ppi (pores per linear inch)
Density:	Medium
Thickness:	1"

The Phase II development consisted of scale-up and mechanical testing. Slabs 24" X 6" X 1" were fabricated and hot static load tests were run for 300 hrs at 1000°C with no measurable deflection, cracking, or shrinkage. Loading was designed to simulate the maximum expected load during operation.

In the third phase of development full-scale, radiused, and machined pieces were produced and assembled on a frame to form a two foot long cylindrical (30" dia) section. This demonstrated that large pieces could be fabricated from Udicell within the tolerances required to complete an assembly. Stepped edges, holes, and counterbores were successfully machined. The Al_2O_3 composition for these pieces was increased to 98%.

Udicell is manufactured by:

HiTech Ceramics, Inc.
P. O. Box 1105
Alfred, NY 14802
(607) 587-9146
ATTN: J. R. MORRIS

V-5 COLLECTOR MATERIALS

The materials in the collector assembly of a full scale U-PSP module will be exposed to highly corrosive molten uranium at high temperatures (1300°C to 1400°C) and, also, to high sputtering rates. The reference process relies on a weakly bonded "wash" coat of yttrium oxide to protect the graphite collector and accumulators. This "wash" coat is similar to that commonly used at Oak Ridge to coat molds for casting uranium. The coatings can be applied much like a low viscosity paint, by brushing or spraying, to a thickness of 0.005" to 0.010". Yttrium oxide "paint" consists of an aqueous suspension of yttria with an organic binder and the "paint" may be purchased from

ZYP Coatings, Inc.
P. O. Box 208
Oak Ridge, TN 37831

The binder can be removed by heating (300° to 500°C) in vacuum. An overcoat layer, such as a carbide, may be necessary on the collector blades to promote wetting. After each cycle (27.5 hours) the entire collector assembly must be refurbished by removing the U/UO_2 film and yttrium oxide coating from the graphite and recoating. In an effort to develop a multi-cycle materials system, SRL investigated other materials and coating processes.

Based on the ease of fabrication, chemical compatibility with molten uranium, coating-substrate thermal expansion match (Figure V-12), and mechanical integrity, a plasma sprayed yttrium oxide coating on a niobium substrate was selected as a possible candidate for an alternative materials system for the collector.

The Plasma Spray Coating Facility in Building 305-M was used to fabricate and analyze alternative materials systems for the PSP collector. The ASTM water immersion test[60], was modified to measure the density of the coatings and a precision of better than 1/2% Theoretical Density (TD) was obtained.

A series of experiments was executed to determine the plasma spraying conditions which tend to maximize the coating density and produce a uniform, well bonded coating. The effects of the feed powder size, powder feed rate, working distance, power level, arc gas flow rate, powder gas flow rate, arc gas composition, nozzle configuration, cathode spacing, plasmagun traverse rate, and indexing distance were investigated. The optimum conditions for plasma spraying dense yttrium oxide coatings are presented in Table V-2. The experimental results, shown in Figures V-13 to V-16, give an indication of the effects of variations in the critical plasma spraying parameters on deposition rate and coating density.

Using the optimum conditions derived from these experiments, yttrium oxide coatings of 94% theoretical density can be plasma sprayed on niobium. Characterization of polished cross-sections with a scanning electron microscope indicated that most of the porosity was in 2 μm wide channels oriented parallel to the substrates surface and between the successive layers of the coating. The next steps in this program involve testing at conditions which closely simulate those expected in the full scale PSP module.

TABLE V-2

OPTIMUM CONDITIONS FOR PLASMA SPRAY COATING
HIGH DENSITY YTTRIA

Coating Material: Y_2O_3

Supplier:	CERAC, Inc.
Particle Size:	-325 mesh, +10 µm

Plasma Gun

Supplier:	Bay State Abrasives, Inc.
Model:	PG 120-4
Nozzle Number:	901065
Cathode Number:	901066
Cathode Spacing:	0.625"

Arc Gas: Argon

Pressure:	50 psi
% Flow:	40%
Flow Rate:	74.5 SCFH
Control Console:	Model CP620 by Bay State

Powder Gas: Argon

Pressure:	50 psi
% Flow:	20%
Flow Rate:	6 SCFH

Substrate: Nb (1/8" X 1-1/2" X 1-1/2")

Cleaning:	Freon, ultrasonic bath
Grit Blasting:	24 grit Al_2O_3 at 50 psi, BN nozzle
Cleaning:	Freon, ultrasonic bath
Drying:	5 min. in vac.

X-Y Traverse

X-Traverse Rate:	50 FPM
Y-Index Distance:	0.10 inches
Working Distance:	3.0 inches
Cooling:	Argon Gas on surface, H_2O on back side

Power

Supplier:	Bay State Abrasives/Miller Electric Mfg.
Model:	PS 2000 60/80 kW
DCV Open Circuit:	80
DCV Operating:	45
DCA Operating:	1217

TABLE V-2 CONT.

Powder Feed

Rate:	0 (on dial) = 20 g of Y_2O_3/min.
Feeder:	Model PF500-3 by Bay State

Coating

Deposition Rate:	1.74 mils/pass
Density:	94% Theoretical Density
Color:	Grey

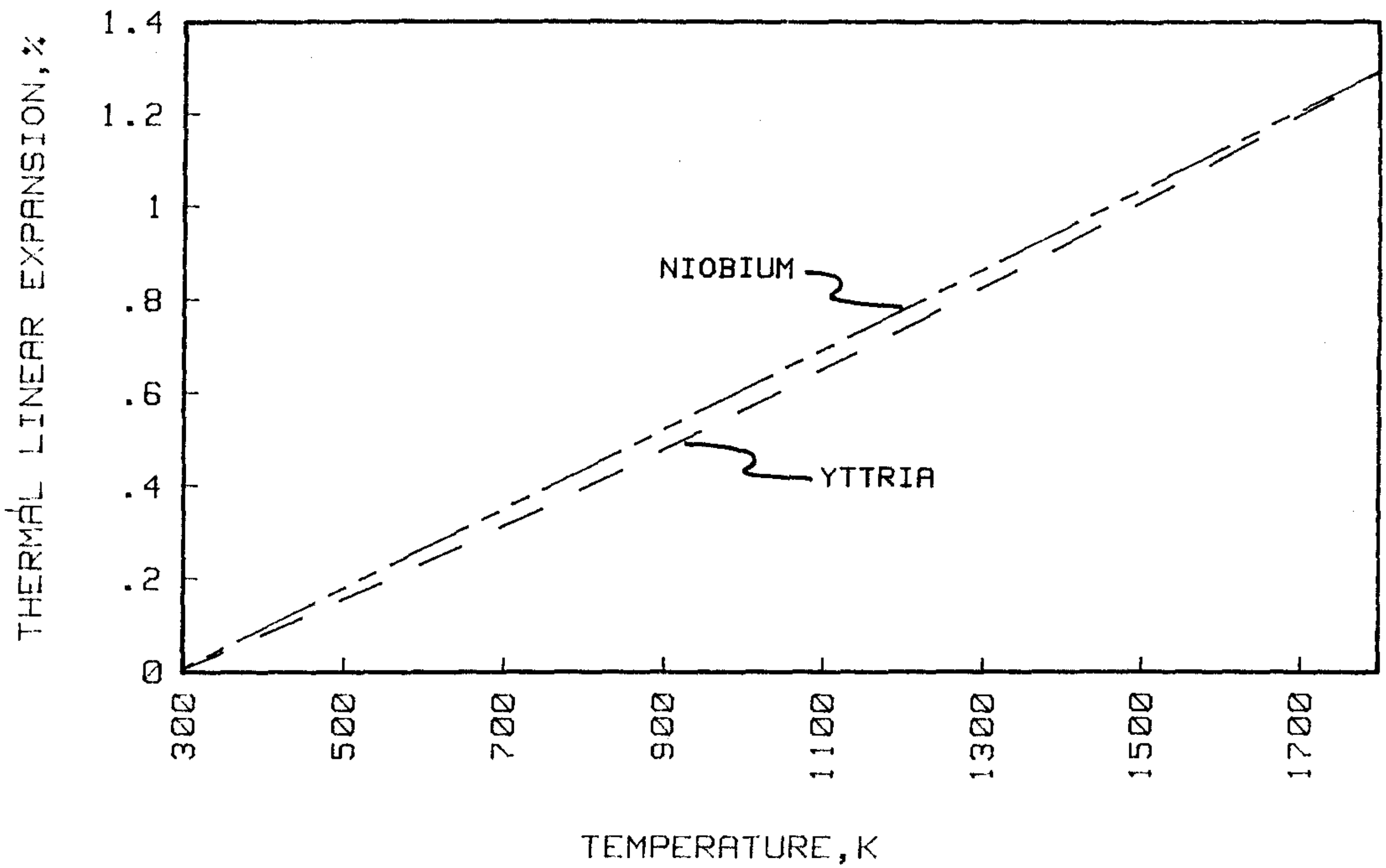


FIGURE V-12. Thermal Expansion of Yttria and Niobium

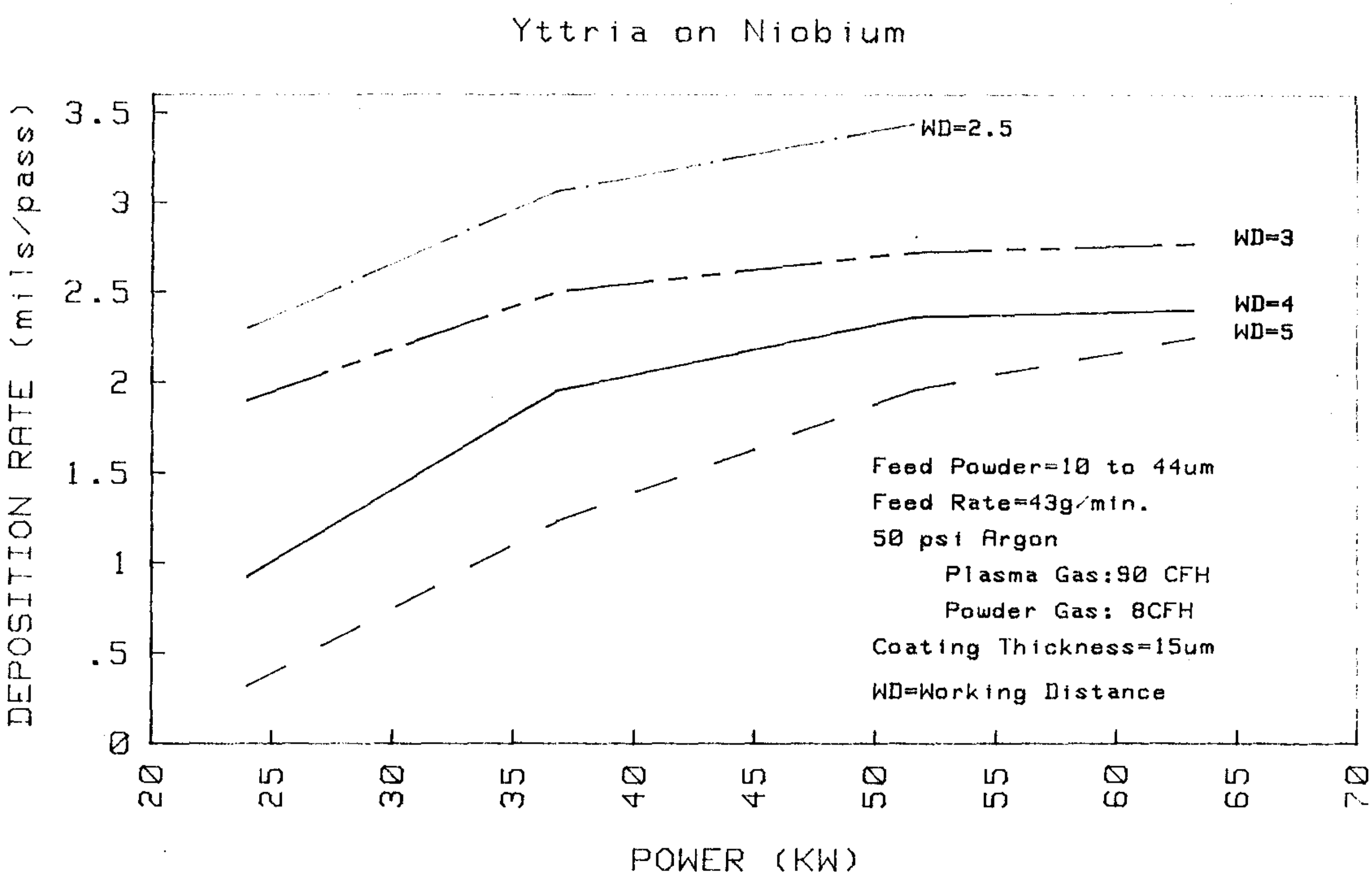


FIGURE V-13. Effect of Power and Working Distance on Deposition Rate

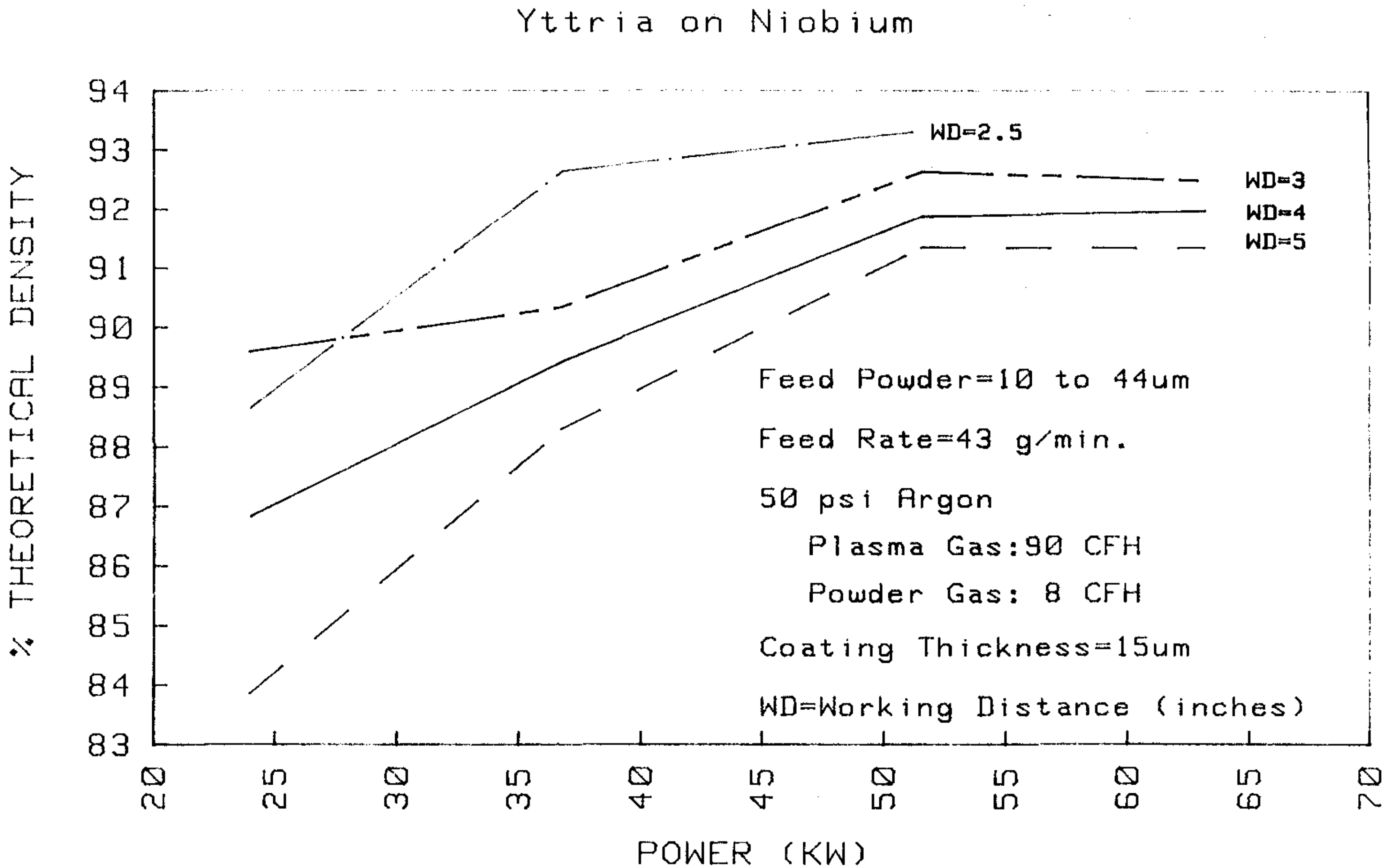


FIGURE V-14. Effect of Power and Working Distance on Coating Density

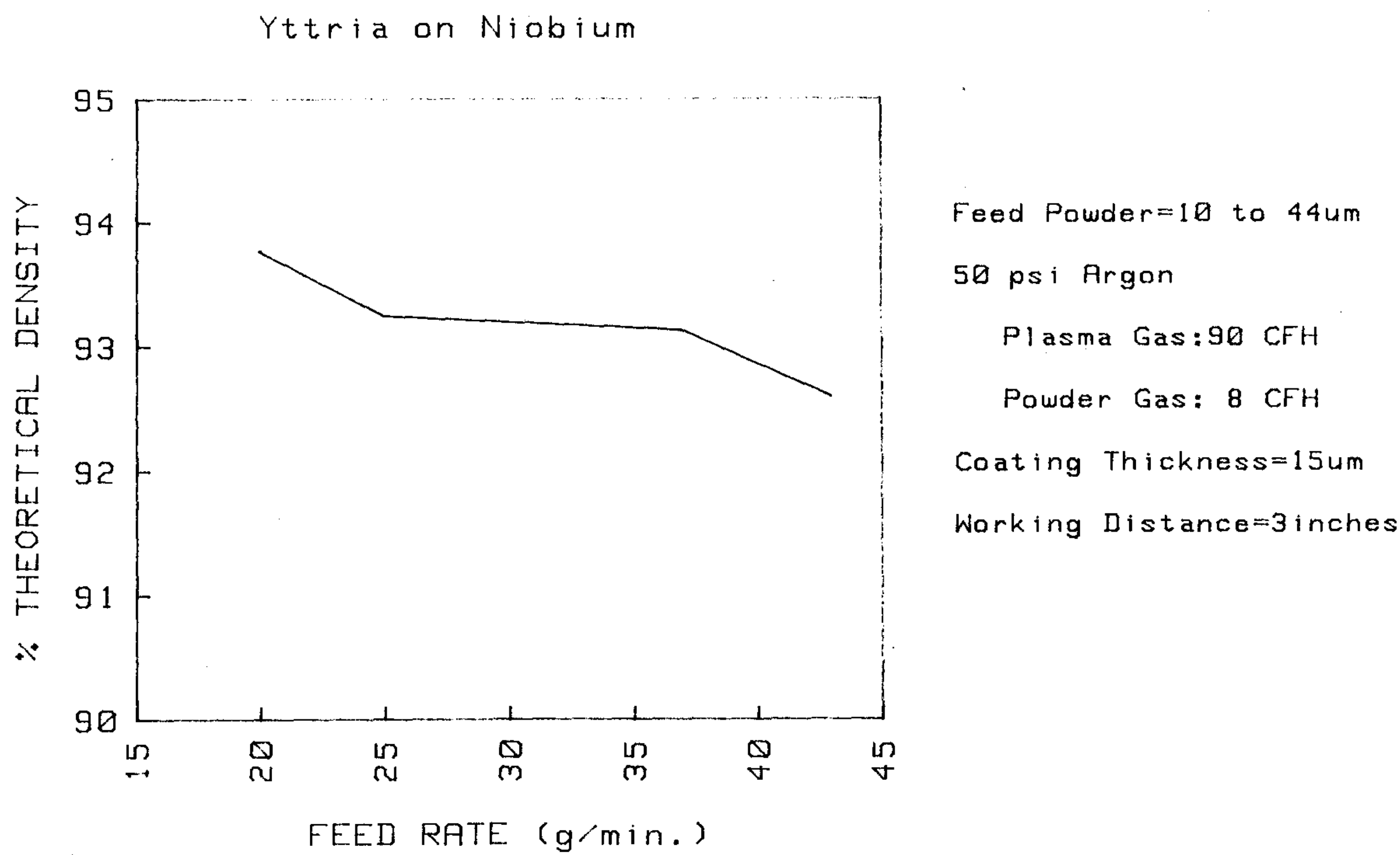


FIGURE V-15. Effect of Feed Rate on Coating Density

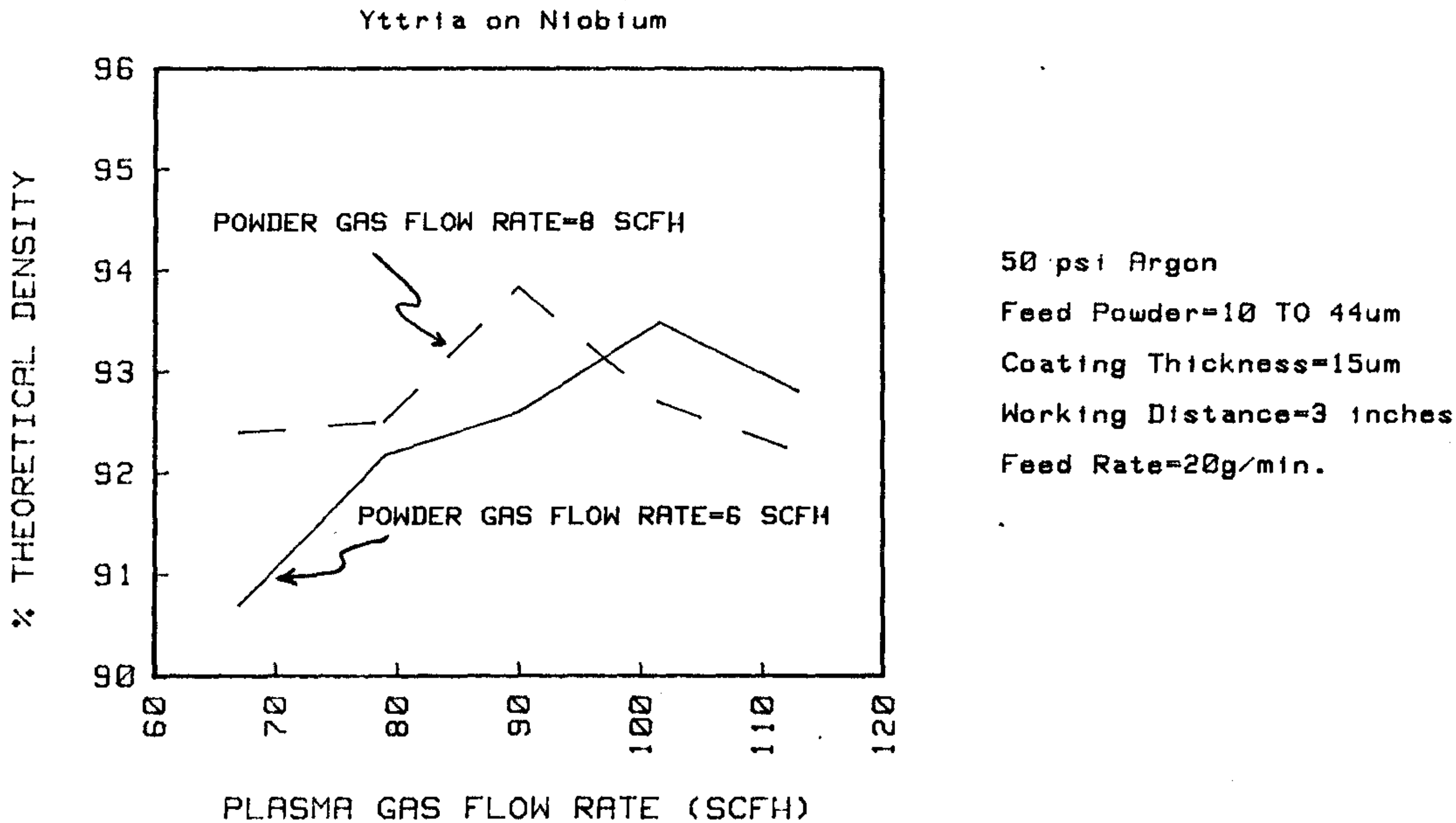


FIGURE V-16. Effect of Powder Gas and Plasma Gas Flow Rates on Coating Density

V-6 PROCESS PHYSICS MODELS

Computer codes for the PSP separator process physics have been written by TRW. A complex code named "Radial Energy Analyzer" uses a Monte Carlo analysis of the separator performance. This code is expensive to run, hard to interpret, and runs at LANL. A simplified code describing the collector region was recently completed and has been transferred to SRL[70].

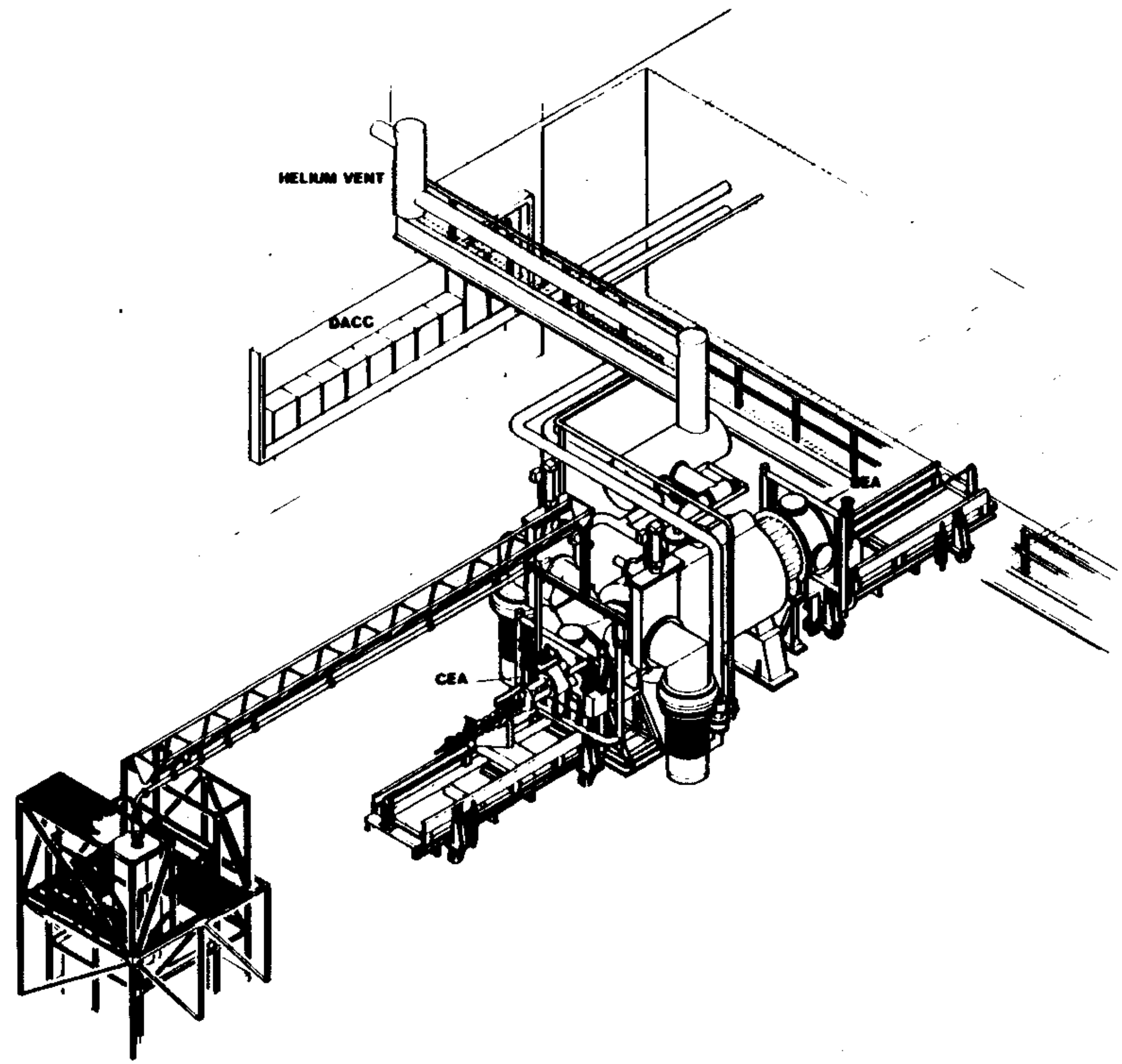
V-7 URANIUM OXIDE SOURCE PLATES

The question has been raised on several occasions if it is possible to use uranium oxide as a source material for the PSP program in order to avoid the requirement for uranium metal. A program was considered[61] to determine the viability and a preliminary program plan was described[62] for the early phase of a development program.

V-8 MAGNETIC FIELD SAFETY

Health and safety issues related to the presence of strong magnetic fields are addressed in a memo by D. W. Howard and F. E. Driggers[71]. In addition measurements were made at TRW of the forces on several items in the TRW laboratory. These are described in Appendix B.

Components Test Module



VI. CTM STATUS

VI-1 PURPOSE OF THE CTM

The Components Test Module (CTM), was designed to provide an experimental facility for development and design verification of major components and subsystems of the PSP plant. It was designed to provide a plasma simulating the plant module in flux, size and power and to accept prototypical plant process hardware. The major objectives of the CTM were:

- verify design of the major module internal components (except the drive coil) by operating at full power and flux levels for continuous runs up to 30 hours.
- Test source heat exchangers and cooling systems to develop a criticality safe source.
- Solve problems of operating a PSP machine inside a containment area.
- Develop and demonstrate techniques for recovery of material from the source assembly and other internal module parts.
- Transfer PSP technology from TRW to SRL.

The Components Test Module was to use depleted uranium and was to operate without equipment for isotopic enrichment.

VI-2 GENERAL DESCRIPTION

The CTM was to consist of a 15,000 gauss magnet with a one meter bore containing a vacuum chamber with all PSP hardware except the ion resonant drive coil. Source plates of 30 and 73 cm were to be operated at 4000 volts with up to 200 kilowatts of 28 GHz microwave radiation generating the uranium plasma. Experiments were to be done with both solid and liquid uranium collection. Evacuation of the process chamber was to be done by two 20" diffusion pumps with 24" liquid nitrogen cold traps. Movement of the source and process hardware was to be done by wheeled transport carts at each end of the vacuum system. A schematic of the CTM installation is shown in Figure VI-1.

Each end of the plasma module was to be enclosed in a transparent containment shelter to vent any air-borne uranium dust to a HEPA filtered exhaust system. This shelter would be built over an eight inch high containment pan covered by open aluminum grating to contain any coolant spills or uranium losses. A barrier wall was to surround the module and gyrotron to restrict access to areas of high voltage or magnetic fields greater than 30 gauss. A special double wall cryogenic exhaust line was built to conduct helium from the magnet in case the magnet went into normal conduction and boiled off the liquid helium. The double wall vent line would prevent air from condensing and dripping off onto equipment or personnel.

Safe operation of the CTM electrical system required a special isolated ground buss to protect personnel and equipment. The high voltage, high current power supplies were expected to arc to ground occasionally and were capable of generating high voltage radiofrequency power during the arc. A ground buss of 6" wide, 1/4" thick copper was provided to carry such current to a special grounding well at the power substation. The well provided a single point ground for three buss bars. One led from the module to the gyrotron to the well. One led from the power supplies to the well and one led from the control room to the well.

A building was built to house the two large power supplies, 90 kV and 4 kV, needed for CTM operations. A new 2500 kW substation was also built to provide AC power for the supplies. A new cooling tower was installed and was to be connected to a 2000 gallon deionized water supply to provide recirculating coolant for the module, gyrotron, and power supplies. A data acquisition and control room was built next to the module area and was to contain all the module and power supply control systems.

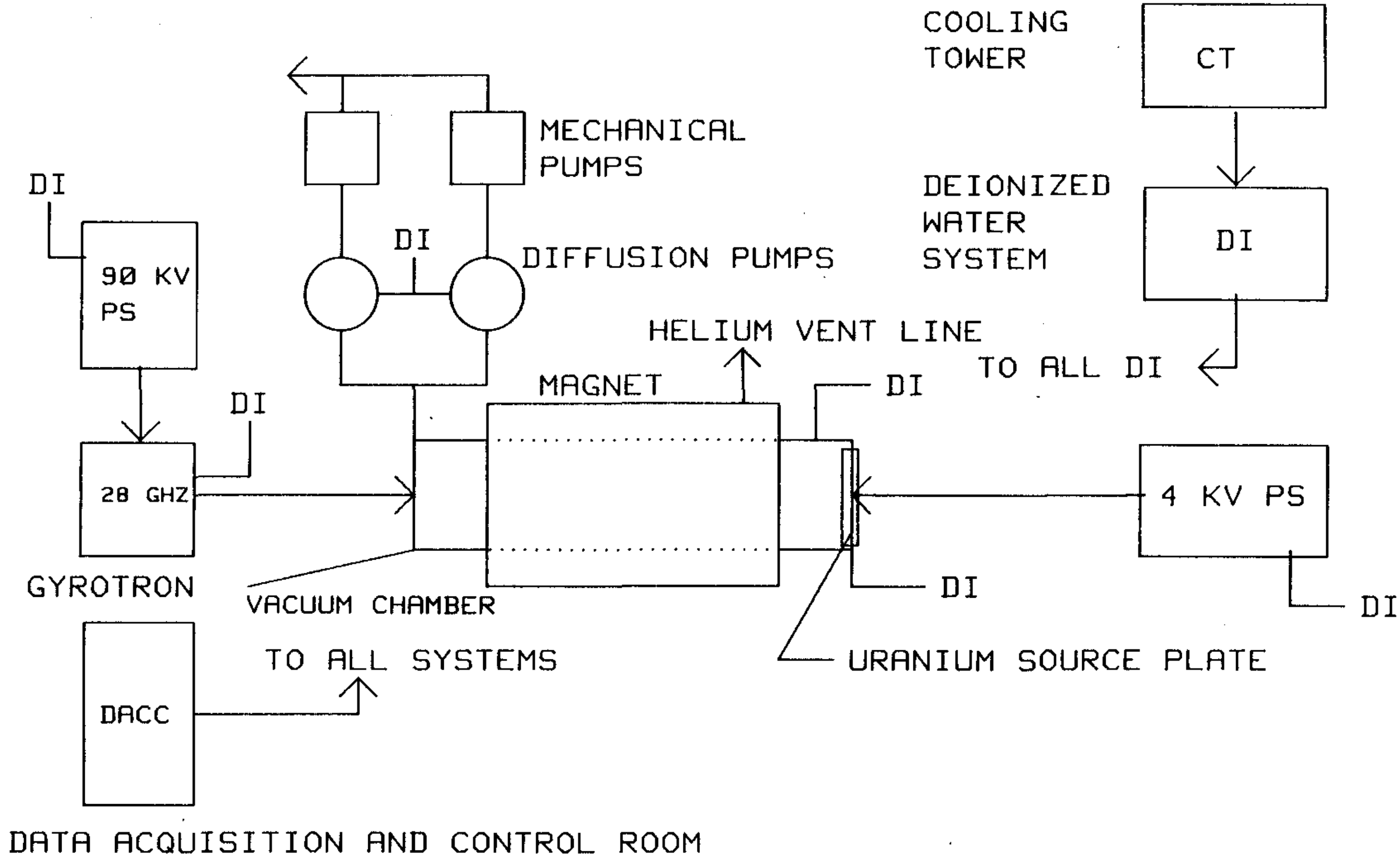


FIGURE VI-1. CTM Schematic Diagram

VI-3 SAFETY CONSIDERATIONS

The PSP machines in operation at TRW are laboratory experiments operating with depleted uranium. A number of issues were to be addressed in the CTM to satisfy DuPont Safety Standards and Criticality Control Standards for an enriched uranium process.

Coolant to remove the large amounts of waste heat from the module was an important problem. Criticality considerations either precluded using water as a coolant or imposed severe limitations on the amount of water in the cooling system. Water coolant also required system protection against build-up of hydrogen (from water-uranium reaction) in the module or in the vacuum system exhaust. Alternative coolants presented problems in source heat exchanger design and toxicity of decomposition products if the coolant reacted with uranium or decomposed in the plasma.

Pyrophoricity of the thin layers of uranium deposited on all internal module walls required development of special equipment and procedures to remove the uranium. An initial design concept was to scrape the uranium into a metal vacuum hose connected to a pre-filter of stainless steel cloth, (to catch burning flakes) and then to a commercial HEPA filtered vacuum cleaner.

High Magnetic Fields over large areas presented problems of safety, facility operation, and effects on other SRL and Plant operations. The CTM superconducting magnet generated a magnetic field of 15,000 gauss within the bore and fields of 100 gauss 10 feet from the center of the magnet. Problems of safety involved restricting access by personnel wearing pacemakers and restricting movement of magnetic materials around the magnet. Facility operation had to insure that magnetic materials, especially tools, would be controlled very carefully and that electrical relays would be shielded or placed outside the 10 gauss region. Interferences with other SRL operations were possible for low fields in electron imaging devices, and unexpected high fields induced in building steel by the magnet. Some photomultiplier tube counting equipment in Plant Operations in Building 735-A were to be carefully tested for gain shifts caused by the CTM magnet. Appendix B describes some of the effects of magnet fields on materials and relays.

High Power Microwave radiation presented unique problems requiring special safety precautions in the CTM. Selection of components for 200 kilowatt, 28 GHz microwave energy was primarily a responsibility of TRW and Varian Co., but successful, safe operation of the equipment required special training of personnel in assembly, care, and radiation leakage testing of the equipment. A training videotape of waveguide assembly and leak testing was made at TRW for use at SRL. It was anticipated that adequate training equipment and procedures would be obtained to accomplish safe operation of the microwave system.

VI-4 EXPERIMENTAL PROGRAM

The experimental program planned for the CTM was:

- Build the Components Test Module in the Building 773-A Fabrication Laboratory.
- Test each CTM sub-system.
- Start up with low power argon plasma and copper source plate.
- Assess effects of magnetic fields on electrical equipment and NIM's.
- Develop operating procedures necessary in case of water or air leaks.
- Operate 30 cm depleted uranium source plates up to full process power densities.
- Develop preliminary uranium cleaning and component handling techniques and equipment.
- Develop and test data acquisition system for diagnostics during full power operation.
- Train operators and technicians in system operation.
- Install a full size source and cooling system therefor.
- Test system operation at full power.
- Develop the source and heat exchanger for FIDF.
- Refine component handling techniques and equipment.
- Develop the liquid uranium collector.
- Initiate new programs as needed for FIDF support.

VI-5 DETAILED DESCRIPTION

The CTM was designed for installation in the 773-A Fuel Fabrication Laboratory. The facility design requirements are detailed in TRW document PSP-SR-116 SRL Components Test Module Facility Requirements Document. All TRW documentation for equipment design requirements, procedures, drawings, etc. is listed in appendix F.

The CTM was to generate a full plant scale ion flux for sources prototypic for the FIDF. Plasma was to be generated by electron cyclotron resonant heating to ionize atoms in a magnetic field of 10,000 gauss (1.0 Tesla). Microwave energy at 28 GHz was to provide heating with power input up to 200 kW. The microwave energy was to come from a single gyrotron tube supplied with DC power from a -90,000 volt, 10 amp power supply. Ion reflux was to be established by a -4,000 volt, 160 amp DC power supply. A drawing of the CTM facility layout is shown in Figure VI-2.

Magnet. The CTM magnet was a commercial superconducting magnet built by IGC Corporation for use in medical imaging by nuclear magnetic resonance. The superconductor was cooled to 4.2°K by a 500 liter liquid helium cryostat. This cryostat was shielded by a vacuum isolated liquid nitrogen cryostat. The magnet bore was 1 meter and the length was 8 feet. Power and control were supplied by instrumentation provided by the vendor. Liquid helium was to be filled into the magnet manually from 500 liter dewars. Liquid nitrogen was to be supplied to the magnet by a vacuum jacketed line connected to a large supply tank outside the building.

A special cryogenic vent line was designed and built to conduct cold helium vapor from the magnet to the outside. In case the magnet "quenched" (went into normal conduction) all the energy stored in the magnetic field would be conducted to the liquid helium causing it to boil suddenly. The exit vapor would be far below liquid air temperature and would be flowing at a high rate. A vent was necessary that would not condense air or generate back pressure on the magnet cryostat.

An acceptance test procedure was written for the magnet and is in Appendix C.

Plasma Chamber. The plasma vacuum chamber was a 38 inch diameter, 128 inch long, water cooled stainless steel cylinder mounted through the bore of the magnet. The chamber was to be evacuated through two 24 inch ID elbows connected to 24 inch liquid nitrogen cold traps and 20 inch diffusion pumps. Mechanical forepumps Stokes Model 1736 which would also serve as roughing pumps. During rough pumping, 50 cfm. Welch pumps were to keep the diffusion pump in a holding state. Two 24

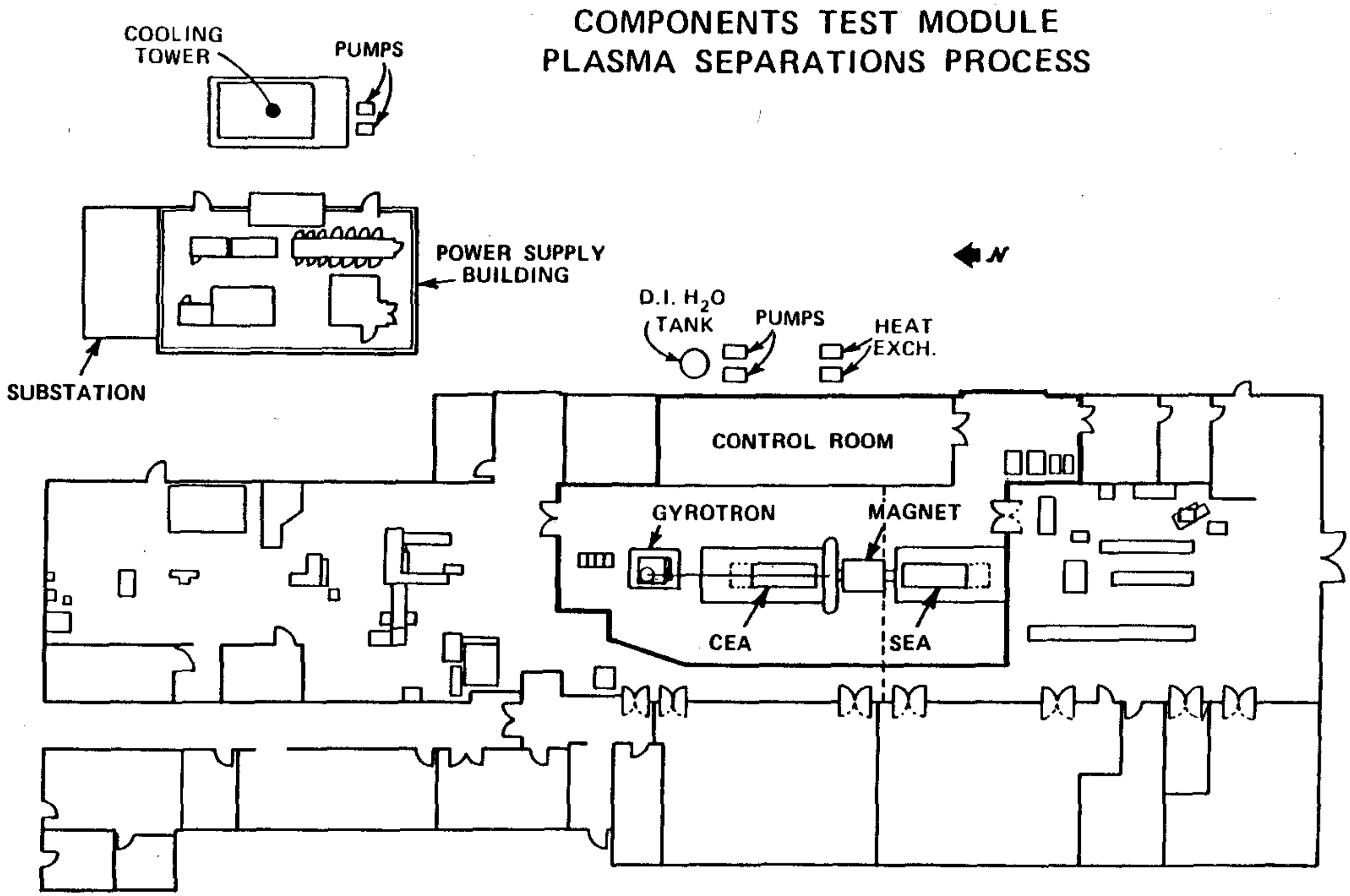


FIGURE VI-2. CTM Layout in Fuel Fabrication Laboratory inch vacuum valves would isolate the diffusion pumps when the plasma chamber was filled with air.

The source end plate was to be sealed to the vacuum chamber by a double O-ring seal. It was to contain electrical and water cooling connections and would support the source plate and heat exchanger. A wheeled transport cart would support the source plate and provide movement to insert and extract the source assembly. An enclosure built of clear polycarbonate sheet was to provide containment of uranium dust. This enclosure was to be vented through HEPA filters to the Fab Lab. The area under the enclosure was to have an 8 inch high containment pan with an open grid cover of aluminum to act as a raised floor.

The collector end plate was to support solid or liquid uranium collectors and supply coolant and microwave to the module. A window with a microwave screen was to provide visual access to module components. A transport cart, containment shelter, and containment pan will also be provided at the collector end of the magnet.

Gyrotron. A gyrotron microwave generator was to provide 200 kW at 28 GHz to the module through a waveguide connected into the vacuum system. The gyrotron tube, Varian Model VGA 8000, was to be mounted on an oil tank base and supported by a Unistrut frame. An outer stand and work platform were to be built to provide protection and vibration isolation for cooling water lines. Power supplies for the gyrotron magnets were to be located next to the outer stand.

Gyrotron Power Supply (90 kV Supply). Power for the gyrotron was to come from a -90,000 volt, 10 amp DC power supply built by UVC Corporation. This power supply was located in an air-conditioned building built to house it and the 4 kV power supply. AC input power was to come from a new substation mounted on the same base as the power supply. Grounding was provided by a grid of heavy copper cable welded into a two foot wide lattice and imbedded in the concrete. A special ground well was to be built for a low impedance ground.

Source Bias Power Supply (4 kV Supply). Source bias voltage was to be provided by a -4,000 volt, 160 amp power supply built by UVC Corporation. This power supply was to be located in the power supply building along with the 90 kV supply. Cooling for both power supplies was to be deionized water supplied at 100 psi pressure. Both power supplies were built with special arc-down protection circuitry to prevent damage when vacuum arcs occurred.

Cooling System. Cooling of the power supplies, gyrotron, and module was to be done by deionized water recirculating systems. A 100 psig system was designed to cool everything but the gyrotron tube which was to be cooled by a 140 psig system. Heat was to be removed from the deionized water using "water to water" heat exchangers and finally transferred to the atmosphere by a new cooling tower installed especially for the CTM.

Data Acquisition and Control Room. An air-conditioned control room was built to contain all measurement and control systems. All major CTM hardware was controlled by individual hard-wired controllers, but automation and operator prompting were to be developed as part of the CTM program. A Hewlett-Packard 9845-C Computer was to be installed to take experimental data and perform control functions through CAMAC I/O equipment.

VI-6 CTM PROJECT

A project for $3 million was written to cover installation of the CTM at SRL. This project was to be administered by LSD, and ISD. A copy of the project and scope of work is in Appendix D. M&E and drawing lists are in Appendix E.

Most of the CTM process equipment would be designed and fabricated or purchased by TRW. The CTM project plan(72) documents the management and control for this combined DuPont/TRW program. A complete listing of TRW documentation and an indentured drawing list is included in Appendix F.

The CRS Sirrine Company in Research Triangle Park, NC, was contracted to provide some engineering and drafting support, and to assist in generating and maintaining a project schedule. A copy of the schedule is included in Appendix G. The indicated milestone at 9/1/84 assumed a final project approval on this date. Approximately ten months were needed to complete design and purchase and install all equipment. A uranium source assembly was scheduled for installation on 7/1/85.

Purchases for major long delivery items had been started in January, 1984. At the time this schedule was produced most of these long delivery items were on site.

At termination of the program a directive was received to store CTM equipment at SRL. Storage was arranged as listed in Table VI-1.

TABLE VI-1

ITEM	DESCRIPTION	LOCATION	TAG #
1	VAC. GAGE CONTROLLER		DI-6621
2	COOLING TOWER PUMP	CONSTRUCTION WAREHOUSE	
3	COOLING TOWER PUMP	CONSTRUCTION WAREHOUSE	
4	DI WATER TANK	CONSTRUCTION WAREHOUSE	
5	DI PUMP-LOW PRESSURE	CONSTRUCTION WAREHOUSE	
6	DI PUMP-HIGH PRESSURE	CONSTRUCTION WAREHOUSE	
7	HEAT EXCH.-LOW PRESSURE	CONSTRUCTION WAREHOUSE	
8	HEAT EXCH.-HIGH PRESSURE	CONSTRUCTION WAREHOUSE	
9	HOFFMAN ENCLOSURES	CONSTRUCTION WAREHOUSE	
10	VACUUM PUMP	CONSTRUCTION WAREHOUSE	DI-6609
11	VACUUM PUMP	CONSTRUCTION WAREHOUSE	DI-6608
12	VACUUM PUMP	CONSTRUCTION WAREHOUSE	DI-6603
13	VACUUM PUMP	CONSTRUCTION WAREHOUSE	DI-6602
14	VAC.PUMP FILTERS (2 BOXES)	CONSTRUCTION WAREHOUSE	
15	BORE TUBE STAND	CONSTRUCTION WAREHOUSE	
16	VAC. CHAMBER STAND	CONSTRUCTION WAREHOUSE	
17	DIFFUSION PUMP, 20"	CONSTRUCTION WAREHOUSE	DI-6607
18	DIFFUSION PUMP, 20"	CONSTRUCTION WAREHOUSE	DI-6606
19	LN2 COLD TRAP	CONSTRUCTION WAREHOUSE	DI-6605
20	LN2 COLD TRAP	CONSTRUCTION WAREHOUSE	DI-6604
21	GATE VALVE, 24"	CONSTRUCTION WAREHOUSE	DI-6598
22	GATE VALVE, 24"	CONSTRUCTION WAREHOUSE	DI-6599
23	HELIUM VENT LINE	CONSTRUCTION WAREHOUSE	DI-6692
24	LN2 TRANSFER LINES	CONSTRUCTION WAREHOUSE	
25	MAGNET STANDS (2)	CONSTRUCTION WAREHOUSE	
26	AIR DRIER	CONSTRUCTION WAREHOUSE	
27	HELIUM TRANSFER LINE	CONSTRUCTION WAREHOUSE	L-26961
28	HELIUM TRANSFER LINE	CONSTRUCTION WAREHOUSE	L-26960
29	HELIUM TRANSFER LINE	CONSTRUCTION WAREHOUSE	L-26959
30	ASSORTED VALVES & FITTINGS	CONSTRUCTION WAREHOUSE	
31	ASSORTED CABLE	CONSTRUCTION WAREHOUSE	
32	MAGNET SHIMS / HARDWARE	POWER SUPPLY BUILDING	
33	MAGNET DIAGN.& VAC.SYST.	POWER SUPPLY BUILDING	
34	VAC. SPARE PARTS	POWER SUPPLY BUILDING	
35	MAGNET	POWER SUPPLY BUILDING	
36	MAGNET CONTROL RACK	POWER SUPPLY BUILDING	
37	90 KV PS. (4 BLUE UNITS)	POWER SUPPLY BUILDING	
38	CAPACITORS (2 PALLETS)	POWER SUPPLY BUILDING	
39	2 PS CRATES	POWER SUPPLY BUILDING	
40	TUBE (CRATE)	POWER SUPPLY BUILDING	
41	GYROTRON BASE (BLUE TANK)	POWER SUPPLY BUILDING	
42	ARGON INJECTION CONTROL	POWER SUPPLY BUILDING	
43	POWER METER	POWER SUPPLY BUILDING	DI-6614
44	AMP HR. METER	POWER SUPPLY BUILDING	
45	RADIATION METER	POWER SUPPLY BUILDING	DI-6620
46	UVC SPARE PARTS-4KV	TRW	
47	UVC SPARE PARTS-90KV	TRW	
48	WATER LOAD	TRW	DI-6617

VII. STATUS OF ENVIRONMENTAL AND SAFETY DOCUMENTATION

Regarding the CTM, a NEPA-Safety-Permits checklist was prepared and submitted to the SRP Environmental and Safety group. It was found that no unusual safety features existed that would require a Safety Analysis Report. It was also found that no further NEPA documentation would be required[63,64].

Regarding the FIDF, a Preliminary Hazards Analysis was issued in February, 1984[65]. This was followed by a more detailed Preliminary Safety Analysis Report in November, 1984[18]. A Final SAR would be the next step, using fault tree methodology as engineering design is finalized to better quantify probabilities of events such as accidental criticality. An Environmental Evaluation Impact Analysis was issued for the FIDF in April, 1984[19], and supplemented information relative to potential environmental impacts was issued in July, 1984[66]. Based on these documents and discussions with DOE environmental personnel, it was found that the FIDF would involve no significant impact and a Memorandum-to-File would be the appropriate NEPA documentation. The environmental issue was therefore closed upon issuance of the MTF on November 29, 1984[67]. If the FIDF is located in the 300-Area, existing permits will cover liquid releases such as sewer and small amounts of cooling water. The DOE has agreed that no Air Quality Control permit will be required[68].

VIII. REFERENCES

1. "Uranium-236 Separation from DOE Enriched Uranium." Letter from R. L. Morgan to J. R. Hilley dated 12/21/82.

2. K. Andringa, et. al., "U-236 Separation from DOE Enriched Uranium", DPST-83-393, (S) April 1, 1983.

3. "Disapproved SRP Cost Order SR-4182", Letter from R. L. Morgan to J. T. Granaghan received February 8, 1985.

4. F. E. Driggers, "Reducing U-236 in SRP Highly Enriched Uranium", DPST-83-208 (S) January 6, 1983.

5. I. M. Macafee "Enriched Uranium Utilization", DPST-83-1008 (C) November 7, 1983 revised 12/12/83.

6. P. L. Roggenkamp, and I. M. Macafee "Unit Cost Study - Fuel Cycle Improvements", DPST-84-257 (S) March 15, 1984.

7. Memorandum, J. S. Allender to E. J. Lukosius, "SRP Fuel Cycle Economics with the FIDF", November 21, 1984 revised January 10, 1985.

8. H. E. Hootman, et. al. "Technical Data Summary for a Uranium Separation Facility", DPSTD-84-93, (S) December 1983.

9. "Module Point Design Description for the U-236 Separation Facility", August 1983, TRWA-97056-0528.

10. R. H. Cornwall, "PSP U-236-Separation Facility Building 305-M, Venture Guidance Appraisal for Evaluation", Letter to A. M. Lander dated December 12, 1983.

11. H. E. Hootman, "Feedplate Fabrication Considerations", DPST-83-969, October 21, 1983.

12. H. E. Hootman, "Rocky Flats Plant Uranium Facilities", Trip Report, May 4, 1983", DPST-83-494 May 9, 1983.

13. A. S. Ferrara, H. E. Hootman, "Oak Ridge Uranium Foundry Trip Report, September 20, 1983", DPST-83-882, September 28, 1983.

14. Ferrara, A. S. et. al. "Trip Report, Oak Ridge, TN, Y-12 Plant, February 1-2, 1984", DPST-84-273, February 3, 1984.

15. Ferrara, A. S. et. al. "Source Plate Fabrication, Rocky Flats Trip Report, March 6-7, 1984", DPST-84-411, March 26, 1984.

16. "Module Point Design Description, SRL Fuel Improvement Program Demonstration Facility", April 1984, TRWA-97056-0562. (S)

17. H. E. Hootman, "Technical Data/Basic Data Summary for a Fuel Improvement Development Facility", DPSTD-83-86, September 1984.

18. Topp, S. V., "Preliminary Safety Analysis, Fuel Improvement Demonstration Facility", DPST-84-584, November 1984.

19. Topp, S. V., "Environmental Evaluation Impact Analysis, Plasma Separation Process Demonstration Facility", DPST-84-424, April 1984.

20. Hootman, H. E., "Dose Burden and Shielding Estimation for PSP Uranium Metal Processing", DPST-84-329, February 29, 1984.

21. Hootman, H. E., "Accountability Plan for the Fuel Improvement Demonstration Facility", DPST-84-369, May 2, 1984.

22. Hootman, H. E., "Functional Description, SNM Management Computer System, Fuel Improvement Demonstration Facility, PROJECT S-4167", DPSTD-84-97.

23. R. K. Leaning, "Conceptual Design Report for a Fuel Improvement Demonstration Facility", (to be issued).

24. R. H. Cornwall, "Fuel Improvement Demonstration Facility, Current Appraisal of Cost", Letter to E. J. Lukosius, (to be issued).

25. Hootman, H. E., "Project Quality Assurance Plan for Fuel Improvement Demonstration Facility", QA-2, December, 1984.

26. H. E. Hootman, F. E. Driggers, K. Andringa, "Technical Data Summary for a Uranium Separation Facility", DPSTD-83-74, April, 1983. (S)

27. H. E. Hootman, "Dose Rate and Shielding Estimation for Uranium Metal Processing Facilities", DPST-83-495. Memorandum to K. Andringa May 20, 1983.

28. H. E. Hootman, K. Andringa, "Minutes SRL-TRW Meeting, June 2-3, 1983", DPST-83-589, June 14, 1983.

29. H. E. Hootman, "Trip Report and Minutes of SRL-TRW Meeting, June 19-20, 1983", DPST-83-701, July 26, 1983.

30. H. E. Hootman, "Minutes of SRL-TRW Meeting, August 23-24, 1983", DPST-83-843, August 25, 1983.

31. "TRW-DuPont Interface Control Document for the Fuel Improvement Demonstration Facility", PSP-6318, June 8, 1984.

32. H. E. Hootman, "Trip Report PSP Magnet Subcontractor Selection, DOE Review Meeting, October 26-27, 1983", DPST-83-1001, November, 1983.

33. H. E. Hootman, F. E. Driggers, "Technical Data/Basic Data Summary for a Uranium Fuel Improvement Facility", DPSTD-84-93, December, 1983. (Secret)

34. H. E. Hootman, "Trip Report and Minutes of SRL-TRW Meeting, February 7, 1984", DPST-84-296, February 10, 1984.

35. R. K. Leaning, "EWR 861826, SRP-300M Area U-236 Separation - Building 305-M Trip Report - Oak Ridge Y-12 Plant, Friday, February 18, 1983".

36. H. E. Hootman, "Minutes of DuPont-TRW Meetings at Louviers and SRP, March 20-22, 1984", DPST-84-417, April 4, 1984.

37. K. Andringa & F. E. Driggers, "Trip Report to UCC/Oak Ridge", DPST-83-309, February 9, 1983.

38. A. S. Ferrara & J. F. Brightharp, "Request for Quotation, Uranium Induction Melter, RFQ #JRB840119-1", April 30, 1984.

39. A. S. Ferrara, "Trip Report - Rocky Flats Uranium Foundry", September 28, 1983, DPST-83-944, October 24, 1983.

40. A. S. Ferrara & P. K. Smith, "Trip Report - Rocky Flats", DPST-83-1074, December 14, 1983.

41. J. M. Hammeter, "RFP Letter to A. S. Ferrara", DPST-85-326, Package 3; January 16, 1985.

42. J. M. Hammeter, "RFP Letter to A. S. Ferrara", DPST-84-326, Package 4; March 1, 1985.

43. A. S. Ferrara & P. K. Smith, "Trip Report - Rocky Flats, May 15-16, 1984", DPST-84-529, May 29, 1984.

44. C. M. Edstrom, "RFP Letter to A. S. Ferrara", DPST-85-326, Package 5; May 11, 1985.

45. J. M. Hammeter, "Static and Centrifugal Casting of Depleted Uranium Shapes with Large Aspect Ratio". Rockwell International, Rocky Flats Plant, Golden CO, RFP-3782, 1985.

46. A. S. Ferrara, "Memorandum - Feedplate Fabrication Considerations, Casting Development Program", DPST-83-1023, November 14, 1983.

47. M. E. Garrison, "Brazing Procedure for 24-Inch by 24-Inch Uranium to Copper Plates". DOE Report Y/DV-199, Oak Ridge Y-12 Plant, Martin Marietta Energy Systems, Inc., Oak Ridge, TN, August 5, 1982.

48. P. K. Smith and A. S. Ferrara. "Trip Report - Visit to TRW on Source Plates, May 5, 1984". DPST-84-544. June 4, 1984.

49. P. H. Payton. "3% Neutral Source Plate which Failed by Melting During Operation". TRW Report PSP-TR-316, October 11, 1983.

50. P. K. Smith and K. Andringa. "Uranium-Copper Plates Brazed at Oak Ridge Y-12 Plant", DPST-85-326, Packages 1,2; March 1, 1985.

51. J. L. Krankota. "Low Pressure Eutectic Bonding of Depleted Uranium to Copper", RFP 3781. Rockwell International, Rocky Flats, Golden, CO, 1985.

52. C. M. Edstrom, "Diffusion Bonding and Roll Bonding of Depleted Uranium to Copper", RFP 3783. Rockwell International, Rocky Flats Plant, Golden, CO, 1985.

53. N. M. Parrott and T. M. Mustaleski. "Brazing of Uranium to Copper", U.S. DOE Report Y/DV-XXXX in preparation. Martin Marietta Energy Systems, Inc., Oak Ridge Y-12 Plant, TN 1985.

54. J. R. Ogren and L. Yujiri. "SRL-Source Feedplate Tests", TRW, Inc. Report PSP-TP-310. April 18, 1984.

55. P. H. Payton, "Process Specification, Joining Neutral Source Plates to Heat Exchanger Material", TRW Report PSP-24P-272. December 8, 1983.

56. D. W. Koerner. "Ultrasonic Evaluation of Copper-Uranium Braze", US DOE Report Y/DV-XXXX in preparation. Martin Marietta Energy Systems, Inc. Oak Ridge Y-12 Plant, TN 1985.

57. F. E. Driggers, "A D_2O Coolant System for the FIDF Module", DPST-85-329, February 27, 1985.

58. R. H. Young, "Thermal Decomposition of the Fluorocarbon FC-75", DPST-85-272, February 28, 1985.

59. R. H. Young, "Reaction of Uranium and the Fluorocarbon FC-75", DPST-85-273, March 6, 1985.

60. ASTM Standard Test Nos. C373-56, C328-56, C326-56, Book of ASTM Standards, Part 13, American Society for Testing Materials, 1967.

61. F. E. Driggers, "Uranium Oxide Source Plate Plan", DPST-84-792, October 11, 1984.

62. F. E. Driggers, "Preliminary Uranium Oxide Program", Memorandum to W. E. Jule, December 14, 1984.

63. Memorandum, J. S. Murdock to H. W. Randolph, "NEPA Environmental Evaluation Form, Components Test Module", November 8, 1984.

64. Memorandum, J. S. Roberts to J. D. Spencer, "Environmental Factor Not Applicable - SRL Components Test Module", November 8, 1984.

65. S. V. Topp, "Preliminary Hazards Analysis for the Plasma Separation Process", DPST-83-1040, February, 1984.

66. Letter, M. M. Anderson to W. E. Wisenbaker, "Supplemental Information EEIA for the Plasma Separation Process", July 19, 1984.

67. Letter, J. S. Roberts to J. D. Spencer, "NEPA Compliance, Memorandum-to-File, FIDF", November 29, 1984.

68. Memorandum, R. M. Guidry to S. V. Topp, "Plasma Separations Process Demonstration Facility", September 25, 1984.

69. J. H. Faupel, F. E. Fisher, "Engineering Design", John Wiley, 1981.

70. F. E. Driggers, "A TRW Computer Model of the PSP Collector and Shroud Region", DPST-85-219, January 8, 1985.

71. D. W. Howard and F. E. Driggers, "Magnetic Field Safety - Progress Report", DPST-85-315, February 20, 1985.

72. "CTM Project Plan", PSP-6421; February 8, 1984.

VGA Documentation

Process Scope of Work, R. K. Leaning, August 3, 1983
EWR-861826
Mechanical Scope of Work, R. G. Everest, October 4, 1983
Power/HV Scope of Work, M. Censurato, August 25, 1983
Electrical Scope of Work, M. Krynock, September 16, 1983
Instrument Scope of Work, R. W. Foster, September 13, 1983
Control Systems Scope of Work, T. K. Holwegner, October 5, 1983

Drawings for VGA

W-737025	Plot Plan
W-737022	Composite Ground Floor Plan
W-737095	Storage Tank
W-737019	Process Area Sheet 3
W-737021	Receiving and Storage
W-737096	Process Area Sheet 1
W-737018	Process Area Sheet 2
W-737020	Foundry Area - Ground Floor
W-737024	Foundry Area - 2nd Floor
W-737023	Process Area - 2nd Floor
W-737221	2nd Floor Composite

CAC Documentation

"Revised Process Scope of Work for CAC", R. K. Leaning April 25, 1984
EWR-861826
"Mechanical Scope of Work", W. R. Tilley, June 7, 1984.
"A and C Scope of Work", G. P. Hurst, July 12, 1984.
"Power/H and V Scope of Work", M. Censurato, May 18, 1984.
"Instrument Scope of Work", C. E. Greef, July 18, 1984.
"Control Systems Allowance for CAC", D. C. Emanuel, July 11, 1984
"Power/H and V Scope of Work Revision I", M. Censurato, November 5, 198
"Building 751-A/1A-115kV Primary Substation", Memorandum from W. T. Schalleur to R. K. Leaning, October 11, 1984.

R. K. Leaning, "Process Hazards Review Report", November 1984.

R. K. Leaning, "Quality Assurance Assessment Meeting", November 12, 1984.

R. K. Leaning, "DA 334, 335 and 336 - Fabrication, Disassembly and Refurbishment Furnaces", Letter to K. Andringa, July 25, 1984.

R. K. Leaning, "Estimate Review Comments", Letter to J. H. Alexander, October 30. 1984.

R. K. Leaning, "Meeting to Evaluate (FIDF Location) Scope Alternatives", Letter to C. Harrison, February 20, 1984.

Drawings for CAC

W-737578	Resistance Furnace - Soldering
W-737580	H_2 Atmos - Glove Box Sh. 2
W-737587	Separator Cooler
W-737590	Shroud Drain & Test Station
W-738257	Process Water System
W-738266	Brazing & Soldering Seal H_O
W-737074	Acid Feed & H_2O Tank
W-735270	Vac. Ind. Furnace
W-736391	Deionized Water System
W-733837	PSP Module
W-737055	Coating Facilities
W-737056	Air Headers
W-737057	Water Headers
W-737058	Inert Gas Header
W-737065	Breathing Air Header
W-737067	Vac. Ind. Furnace - Control Panels
W-737072	Helium Addition
W-734321	Air Monitoring - Low Volume
W-734320	Air Monitoring - High Volume
W-734323	Air Lock System
W-735063	Pickling Facilities
W-735064	Product Recovery Slab Tank
W-735088	Liquid N_2 Stg. Tk.
W-735230	Vac. Ind. Furnace
W-737075	Vac. Cleaning System
W-737577	Resistance Furnace - Brazing
W-737579	N_2 Atmos - Glove Box Sh. 1
W-737023	2nd Floor - Process Area
W-738296	2nd Floor - Process Area
W-737024	2nd Floor - Foundry
W-737022	Ground Floor Composite
W-741245	Section B-B
W-741247	Section E-E
W-741246	Section D-D
W-741241	Sections A-A & C-C
W-737018	1st Floor Process Sh. 2
W-737096	1st Floor Process Sh. 1
W-737095	Grd. Fl. Office Area
W-737019	Grd. Fl. Office Area
W-737021	Receiving & Storage
W-737020	Foundry Area
W-741643	Tank Farm
W-738221	2nd Floor Composite
SW-737025	OSOH & OSUG Lines Plot Plan
W-743082	Grd. Flr. Exh. Duct Study
W-743083	2nd Flr. Exh. Duct Study

Drawings for CAC (Cont.)

W-743075	Grd. Flr. Supply Duct
W-743076	2nd Flr. Supply Duct
W-743902	Exh. Fan Equip. & Duct Arrgt.
W-743450	HEPA Filter Equip. & Duct Arrgt.
W-743451	Power Equip. Arrgts. Plans
W-742878	Instr/Plant Air Diagram Sh. 1
W-742879	Instr/Plant Air Diagram Sh. 2
W-737048	Cooling Tower Water Diag.
W-734322	Air Monitor Blowers
W-742441	Brine Piping Diagram
W-742840	Breathing Air Diagram
W-737025	Process Plot Plan
W-744716	Casting Area Glovebox
W-744717	Casting Area Glovebox
W-744718	Assay Area Glovebox
W-743696	Ind. Furnace Glovebox
W-744708	Milling Machine Glovebox
W-741541	Mold Fixture
W-742230	Storage Rack
W-742220	Walk Thru Area Glovebox
W-741535	Pickling Glovebox
W-742209	Copper Entry Area
W-742230	Pickling Basket
W-743264	Brazing Area Glovebox
W-743644	2nd Floor Arrgt.
W-743263	Soldering Area Glovebox
W-743635	Resist. Furnace Glovebox
W-743639	Resist. Furnace Cooler Glovebox
W-742273	Retort Area Glovebox
W-742375	Retort Area Glovebox
W-742396	Retort Area Glovebox
W-741501	Brazing Fixture
W-741506	Soldering Fixture 209
W-742217	Retort Turning Fixture
W-742243	Retort Rotation Car
W-743262	Waste Hdl'g Glovebox
W-744732	Vertical Glovebox Connection
W-743634	Clean Component Glovebox
W-743627	Clean Component Conveyor
W-743288	Clean Component Conveyor
W-743291	Clean Component Pallet
W-743299	Upper Shredder Encl
W-743290	Shredder Conveyor
W-744733	Lower Shredder Encl
W-742397	Cooling Hood
W-742356	Cooling Hood
W-742911	Cooling Hood

Drawings for CAC (Cont.)

W-742940	1st Floor Arrg't.
W-742928	Module Assy Glovebox
W-742930	Module Assy Glovebox
W-743665	PSP Module TUG
W-742241	Module Transfer Car
W-742901	Used Component Glovebox
W-742902	Used Component Glovebox
W-742903	Used Component Glovebox
W-742904	Used Component Glovebox
W-742905	Used Component Glovebox
W-742906	Used Component Glovebox
W-742277	Separator Storage Rack
W-743283	Refurbishment Glovebox
W-743284	Refurbishment Glovebox
W-743285	Refurbishment Glovebox
W-743700	Window Shielding
W-743261	HEPA Filter Mtg.
W-743630	Floor Support Structure - Glovebox
W-739560	Storage & Retrieval Crane
W-740113	Catwalk
W-743695	NDA Area Glovebox
W-744710	Charge Prep Glovebox
W-744711	Charge Prep Glovebox
W-742379	Roller Conveyor
W-746409	Details & Sections Sh. 1
W-746412	Details & Sections Sh. 2
W-745773	2nd Floor (EL 15'-0") Plan
W-745772	Ground Floor Plan
W-747365	Plot Plan 562
W-747387	Ground Floor Plan
W-747715	2nd Floor Plan

APPENDIX A

MEMO FROM ENGINEERING DEPARTMENT TO H. E. HOOTMAN

EN-1029

DU PONT

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED

WILMINGTON, DELAWARE 19898

ENGINEERING DEPARTMENT

cc: E. J. Lukosius, AED, SRP
A. Bobik, AED, PD #2
P. C. Fithian, AED, PD #2
R. H. Cornwall
C. Harrison
H. O. Aaron
E. J. Hackman
W. R. Tilley
R. G. Brooks
F. S. Stidham
IC 33 (2)

January 25, 1985

H. E. HOOTMAN 773-A
PETROCHEMICALS DEPARTMENT
ATOMIC ENERGY DIVISION
SAVANNAH RIVER PLANT

WR 861826 - SAVANNAH RIVER PLANT - 300M AREA
FUEL IMPROVEMENT DEMONSTRATION FACILITY - BUILDING 305M
EQUIPMENT ARRANGEMENT AND CAC SCOPE REVIEW - 1/17/85

1. Equipment Arrangements

The equipment arrangement drawings: W-801150 and W-801151, which you, Bob Brooks and I reviewed on January 17, 1985, will be included as part of the "Key Drawings" package in the Conceptual Design Report which is being assembled. They represent and confirm the latest arrangement agreement between the AED and Design.

2. Glove Box Volume

The gloves boxes* shown on the above arrangements scale 552 ft, which assuming an average width of 4 ft and height of 11.8 ft, translates into a volume of 26,000 cu ft. This figure along with the 57,000 sq ft for total building floor area, is specified in the "Summary Scope of Work" included in both the Process Scope of Work and the CAC Estimate.

3. Glove Box Windows and Gloves

The projected "operating" side glove box area opposite the casting furnaces, solder/braze furnaces, module component cooling equipment, assembly/disassembly storage area and shredder totals 8500 sq ft. Included in the CAC are 204 shielding window assemblies which at 10 sq ft per window amounts to 2040 sq ft or about one-quarter the total "operating" side. The CAC includes 810 glove ring assemblies or about four per window. You expressed a need for only two glove openings per window - a savings of 402

*NDA room glove boxes are not included.

units. Also, the CAC does not reflect the lower cost laminated and adhesive bonded 4.8 density lead glass windows requested in K. Andringa's letter of June 25, 1984, to C. Harrison.

I talked to Bill Tilley about the glove deletions and laminated window approach. He feels both items should stay as is in the CAC but identified as a future cost reduction actions when the project is restarted - possibly FY'87.

As you requested, windows are not required on the "maintenance" sides of glove boxes servicing both furnace lines where source plate casting, assembly and disassembly operations will be performed. The CAC includes 65 plate glass windows, but it looks like this quantity is sufficient for ceiling light windows only. About 60% of the ceiling area would be glazed.

4. DA M338 - Refurbishment Facility

As you pointed out, the scale of the module cooling hood indicates it is larger and has more gloves than required. This item is also marked for cost reduction work when the project is reactivated.

5. DA M955 - UPS

One Uninterruptive Power Supply (UPS) will be provided to maintain operation of the glove box and hood exhaust fans during the interim between a power failure and emergency diesel generator start-run condition. Separate UPS systems for DA M342 "Separations Modules" and DA M408 "SNM Accountability Facilities" will either be provided by others (TRW) or integral with the equipment.

6. Basic Data and Scope Development Issues

As we discussed, the following areas of Basic Data and Scope need additional work to minimize changes during the course of the project if final design were to proceed:

- The cooling media for the Separation Module source, drive, bore tube, wave guide and collection/withdrawal equipment is liquid fluorocarbon: Fluorinert FC-75. As you told me, recent experiments at SRL indicate toxic degradation (about 5%) products are formed at about 700°C. D_2O and compressed inert gas (He or N_2) cooling systems are under investigation by yourself and SRL. A liquid cooling system (which could leak with resultant steam generation) would require a relif valve be installed on the vacuum vessel (bore tube end flange).

- The composition of passivated uranium metal films is presently indicated as 20% oxide/80% metal. Experience is limited to work done at Oak Ridge on samples. Experiments with films on process module components need to be done to quantitatively determine the inert gas-air mixture compositions and rates required for controlled passivation at the end of each operating cycle to minimize uranium fire hazards.

- The designs and refurbishment operations for module components are on paper only. Simulation techniques with full scale models and Savannah River Plant involvement has yet to be planned and done.

- As uranium accumulates on the collector slats and shroud during the batch cycle, supplemental heating is required to keep the molten uranium sufficiently liquid (above 1133°C M.P.) at low enough viscosity to flow by gravity to the collector pots and hold residual film thicknesses to a minimum. Inadequate heating will result in thicker films, metal "sags" from lack of flow and probably a granular surface condition. This results in a greater exposed area which increases the reactivity during passivation. Collector supplemental heating requirements are estimated as 60 kW for electric heaters to be designed and installed at the collector (accumulator) in the module by TRW. The power level specified suggests incompatibility between the physical dimensions of heaters versus the limited space available in the module at the collector.

- Savannah River Plant operating experience and/or precedent is lacking both with spray applications of rare earth (Yttria) slurries to new and used graphite and Tantalum components and removing Angstrom thick layers of oxidized uranium foils from component surfaces.

- The equipment arrangement, material handling operations, sequences and functional description needs a thorough joint review by AED liaison and Design.

- Although the initial Process Hazards Review and Quality Assurance Assessment is to be issued in February, a review of the facility arrangement with Wilmington and Plant Fire and Safety will be required when the project restarts.

- After equipment arrangement agreement is reached between the AED and Design, it is foreseen that considerable time and effort will be required to obtain TRW concurrence with the building arrangement and settle "Interface Document" details.

- o Expected impurities include Yttria, Copper, Graphite, Nickel and braze compounds in the uranium heel. A process to remove these impurities e.g. solvent extraction, has to be defined and designated.

- o Overall process attainment determination including plate casting and fabrication, heating and cooling estimates, recycle and refurbishment and passivation is incomplete. All HEU casting experience to date is concentrated at Rocky Flats and Oak Ridge. Savannah River Plant has no operating experience with HEU casting.

- o At the time the VGA was transmitted (12/12/83) TRW's package cost was based on a Lump Sum Contract. As we all know, TRW changed their scope and cost estimate in 1984 to reflect a Cost Plus Fixed Fee Contract (CPFF). A CPFF Contract offers a greater scope growth potential than a Lump Sum Contract would for the TRW system. Procedures to control TRW's scope have to be prepared.

Would you please keep me advised of progress on work at SRL and at TRW. Thank you again, Harry, for your help and input.

DESIGN DIVISION
Atomic Engineering Section

R. K. Leaning
R. K. Leaning
Project Engineer

RKL/cms
rkl1:59

APPENDIX B

MAGNETIC EFFECTS ON MATERIALS AND RELAYS

EFFECT OF MAGNETIC FIELD ON MATERIALS AND RELAYS

Introduction

Two brief studies were made to determine effects of magnetic fields on ferrous materials and relays in the vicinity of the CTM magnet. These studies were made for fields less than 150 gauss because it is accepted that very strict control measures are necessary for fields above this level. Part of the operating procedure for any superconducting magnet must be devoted to keeping magnetic materials out of fields exceeding 150 gauss.

Studies

Material Effects. The first study was made of magnetic field effects on materials typical of those that might be transported through the Fabrication Laboratory near the magnet. Long pipe, flat sheet metal, and steel carts were moved through fields of 25 150 gauss near the TRW magnet at Redondo Beach, CA. Measurements were made of torque on the objects using a spring-type scale.

In regions of 120-150 gauss the forces on large steel pieces is sufficient to deflect their orientation and pull them toward the magnet if they are mounted on wheels. A more disruptive effect occurs when two or more pieces are brought close together or a single piece contacts a steel building structure. Forces from induced magnetism cause the pieces to stick together. An outstanding example of this is the unexpected closure force on steel doors. The closure force becomes large as the doors come close together, thus causing an unusual and unexpected pinch hazard. Table 1 lists torques measured on various pieces in 120 gauss field. Figures 1 through 5 are pictures of illustrating various effects in fields of 25-120 gauss.

Relay Operations. A second study was made of relay operation in magnetic fields. It was found that sensitive relays can be made to operate by a field of 25 gauss and that heavy contactors can be made to operate by 75-150 gauss fields. Since the 25 gauss field from the CTM magnet extends more than 20 feet from the center of the magnet, procedures were needed to either disable or to shield relays within this distance. It was anticipated that high fields could be present close to building steel at spots remote from the magnet. Detail surveys with a portable gauss meter were planned to find any such problem areas.

TABLE 1

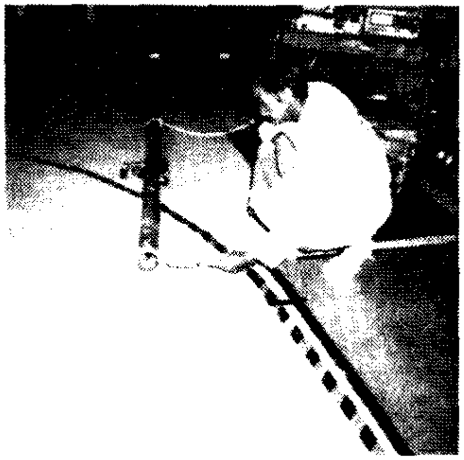
TORQUE ON OBJECTS LOCATED IN 120 GAUSS FIELD

OBJECT	OBJECT WEIGHT (lbs.)	OBJECT SIZE (Inches)	TORQUE (ft-lbs)
Large pipe	50.4	3.5 D X 120 L	20
Small pipe	23	1.0 D X 240 L	12
Large steel plate	16.3	20 L X 48 W	8
Small steel plate	8.5	20 L X 32 W	3.8
Long Unistrut	13.8	1 5/8 X 86 L	6
Short Unistrut	7.8	1 5/8 X 51 L	6.3

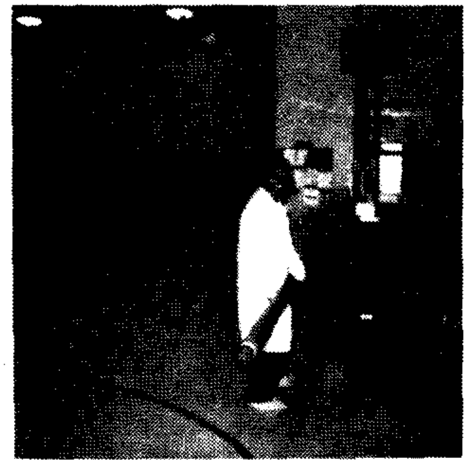
TABLE 1

TORQUE ON OBJECTS LOCATED IN 120 GAUSS FIELD

OBJECT	OBJECT WEIGHT (lbs.)	OBJECT SIZE (Inches)	TORQUE (ft-lbs)
Large pipe	50.4	3.5 D X 120 L	20
Small pipe	23	1.0 D X 240 L	12
Large steel plate	16.3	20 L X 48 W	8
Small steel plate	8.5	20 L X 32 W	3.8
Long Unistrut	13.8	1 5/8 X 86 L	6
Short Unistrut	7.8	1 5/8 X 51 L	6.3



20 FOOT POUNDS TORQUE ON STEEL PIPE, 3.5 IN. DIA. X 10 FT. LENGTH, 50 LBS. WT.



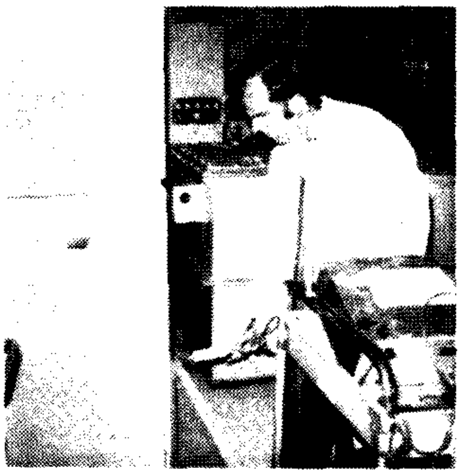
TEN FOOT PIPE IS DIFFICULT TO HOLD STRAIGHT BY ONE PERSON

6 FOOT POUNDS TORQUE ON STEEL CART WITH 143 LBS. TOTAL WEIGHT. CART ALIGNS TOWARD MAGNET BY ITSELF.

6.3 FOOT POUNDS TORQUE ON 4 FT. UNISTRUT, 7.8 LBS. WT.

FIGURE 1. Objects in 130 Gauss Field

SHORT LENGTH OF UNISTRUT STICKS TO STEEL CART- 12 POUNDS FORCE REQUIRED TO PULL LOOSE.

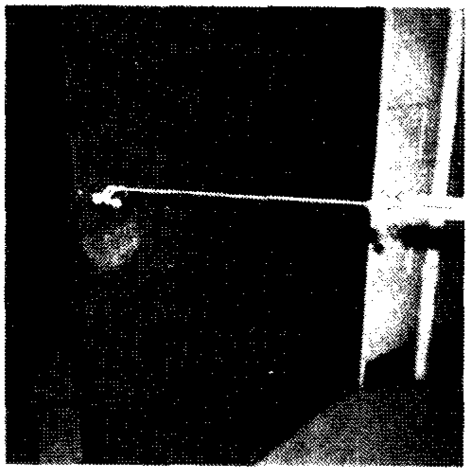


STEEL PLATE STICKS TO AIR CONDITIONER FRAME. 5 POUNDS FORCE REQUIRED TO PULL LOOSE.

STEEL PLATE STICKS TO CART AND SUPPORTS ITS WEIGHT.

FIGURE 2. Interaction of Magnetic Materials at 25 Gauss

MEASURING FORCE
PULLING THE RIGHT HAND
DOOR TOWARD CLOSURE.
FIELD IN REGION, 60 GAUSS



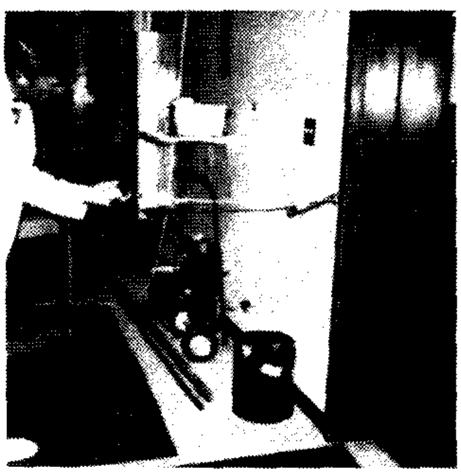
DISTANCE FROM EDGE OF DOOR TO REST POSITION, INCHES	CLOSING FORCE POUNDS
23 5/8	0
18 3/8	5
11 3/4	10
7 1/8	15
4 3/4	20
2 3/4	25

WHEN THE DOOR IS CLOSED,
50 LBS. FORCE REQUIRED
TO PULL IT OPEN.

FIGURE 3. Magnetic Force Closing Double Steel Doors

STEEL PLATE ALIGNS WITH FIELD TOWARD "POLE" LOCATED OFF THE END OF THE MAGNET FIELD = 120 GAUSS

STEEL PLATE ALIGNS WITH FIELD PARALLEL TO THE MAGNET AT MAGNET MID-PLANE, 100 GAUSS

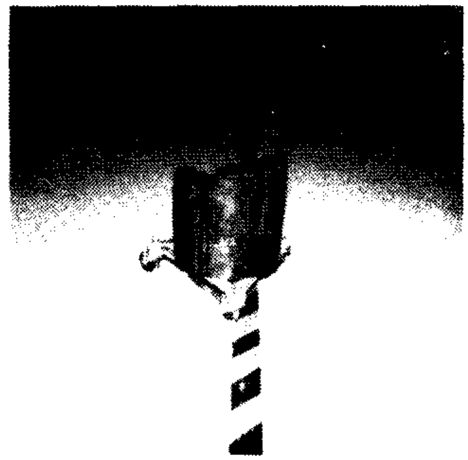


5 POUNDS REQUIRED TO PULL WRENCH FROM DOOR. 60 GAUSS IN DOOR REGION

8.5 LB. STEEL PLATE STICKS TO DOOR FACING, 60 GAUSS

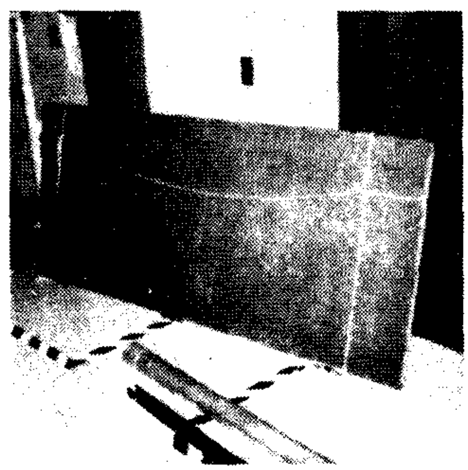
FIGURE 4. Field Effects at 60 to 120 Gauss

6 FOOT LBS. TORQUE ON COMPRESSED GAS CYLINDER AND CART. FIELD = 100 GAUSS.



NEGLIGIBLE TORQUE AND PULL TOWARD MAGNET, 100 GAUSS.

STEEL PLATE STICKS TO PERSONNEL LIFT IN FIELD OF 110 GAUSS.



STEEL DOOR IS SUBJECTED TO TORQUE THAT IS NEGLIGIBLE COMPARED TO DOOR WEIGHT IN FIELDS TO 120 GAUSS.

FIGURE 5. Miscellaneous Items in Magnetic Field

APPENDIX C

SPECIAL PROCEDURE FOR ACCEPTANCE TEST OF THE CTM MAGNET

SPECIAL PROCEDURE FOR ACCEPTANCE TEST OF THE CTM MAGNET

Purpose

Summary

This procedure describes tests to verify safety and proper operation of the superconducting magnet purchased from Intermagnetics General Corporation (IGC) for the Components Test Module (CTM). The procedure will be used by personnel from Isotope Separations, IGC and TRW Co. to perform the tests. The following major segments of work will be done:

- o Confirm that all magnet procedures and facilities are ready and leak check the magnet. Record 300°K electrical measurements.
- o Cool the magnet to 77°K (liquid nitrogen) and record 77°K electrical measurements.
- o Cool the magnet to 4.2°K and record 4.2°K electrical measurements and helium boil-off rate.
- o Startup the magnet and measure magnetic fields outside the CTM controlled area.
- o Measure ramp time to 1.5 Tesla and check field stability and uniformity.
- o Induce a magnet quench at 1.5 Tesla and test the helium vent.
- o Check for any damage from the quench and re-cool the magnet. Record 2°K electrical measurements and helium boil-off rate.
- o Correct any problems or deficiencies in the magnet and compare all test results against the magnet purchase specifications.
- o Begin normal operation of the magnet.

The procedure describes safety hazards and operations unique to the superconducting magnet and will not describe general laboratory procedures, standard electrical measurement procedures, or standard vacuum and leak check techniques.

PROCEDURE

Section 1. Facility Checkout

1.1 Have all personnel performing or observing the tests read attachments on cryogenic and magnet safety. All personnel around the magnet should understand these hazards.

1.2 Have all personnel performing the tests read the procedure.

1.3 Check that the following materials are on hand:

- o CTM vacuum and diagnostic system.
- o One Teledyne-Hastings thermocouple readout for the cryostat vacuum gauge.
- o Portable gauss meter.
- o Two inch line for temporary helium vent to outside.
- o Helium and nitrogen gas with regulator for 0-10 psi pressure. The gas supply bottles must be non-magnetic or else kept far enough away from the energized magnet so as not to be pulled by the magnetic field.
- o Liquid nitrogen (approximately 4000 liters for cooldown).
- o Liquid helium in non-magnetic vessels, 2500 liters.
- o Liquid helium transfer line.
- o Hewlett-Packard Model 3468A Digital Multimeter or equivalent.
- o AMI Model 210 Temperature Sensor Readout.
- o Liquid Nitrogen Fill/Purge Accessory (Ref. Dwg. B9651-217).
- o Helium Refill Guide Tube-Valve Assembly (Ref. Dwg. C9651-218).
- o Ladish Tee Fixture (Ref. Figure 3-1).
- o Gas Heater for Warmup.
- o Thermocouple Gauge Backfill Fixture.
- o Precision gauss meter.
- o Two channel strip chart recorders.

1.4 Verify that installation and testing have been completed on the following systems:

- o Magnet mounting per TRW procedure.
- o Magnet electrical supply and electronic control console.
- o Liquid nitrogen supply line.
- o Helium quench vent line.

1.5 Perform relief valve and rupture disc tests as described in procedures PSP-1, PSP-2 and PSP-3. Send results to IDP files.

1.6 Connect a temporary 2 inch vent line from the helium rotameter to outside the building. This line is to vent the large volume of helium boiled-off during cool-down and prevent accumulation of any volumes of low oxygen air in the Fab-Lab.

1.7 Evacuate and leak check all magnet cavities. Leak rate vacuum jacket should be less than 2×10^{-9} at cc/sec. Other cavities should be less than 1×10^{-6} at cc/sec.

1.8 Verify that the vacuum cavity pressure is less than 20 microns.

1.9 Measure and record 300°K electrical readings per manufacturer's checklist #A910896 and liquid helium probe test data list.

Section 2 - Cool Magnet to 77°C (This procedure requires approximately 48 hours)

To cool the magnet, the liquid nitrogen chamber, 30°K shield, and the magnet space are first filled with liquid nitrogen. Once the system achieves thermal stability at 77°K, the liquid nitrogen is blown out of the magnet space and shield cooling line. After all of the liquid nitrogen has been removed from the magnet space and cooling line, cooling to 4.2°K is accomplished by filling the magnet space with liquid helium. After initial cooldown, the nitrogen and helium chambers will require refilling periodically.

WARNING: Large amounts of nitrogen (non-life-supporting) gas will be evolved during cooldown. The magnet facility should be well-ventilated to insure room oxygen is not depleted or displaced during cooldown.

2.1 Attach a dry nitrogen gas line to the 1/2 inch liquid nitrogen fill port. Open the liquid nitrogen vent valve and the nitrogen flowmeter valves.

2.2 Flow dry nitrogen gas through the liquid nitrogen tanks for 5 minutes at approximately 2 CFM.

2.3 Close the liquid nitrogen vent valve and nitrogen flowmeter valve.

2.4 Close the 30°K shield flowmeter valve, high current lead vents, shim lead vent and cap the liquid helium fill port.

2.5 Remove the helium vent flowmeter assembly and install a 1-1/2 inch Ladish Tee. (Ref. Figure 3-1)

2.6 Install the gauge and back fill assembly to the Ladish Tee.

2.7 Attach the vacuum pump to the Ladish Tee.

2.8 Evacuate the magnet/liquid helium space to <500 millitorr.

2.9 Backfill the magnet/liquid helium space with dry nitrogen gas through the backfill valve to atmospheric pressure (0 psig).

2.10 Remove the vacuum pump hose from the Ladish Tee and seal this port with a Ladish blank flange.

<u>CAUTION</u>: No port on the nitrogen tanks, magnet space, or 30°K vent line should be left open without a positive gas flow outward through the port. Otherwise, cryopumping of air/moisture will occur, clogging lines with frozen air/ice.

<u>**Liquid Nitrogen Cavity Cooldown**</u>

2.11 Insure that the liquid nitrogen vent flowmeter valve is closed.

2.12 Connect the liquid nitrogen supply line to the 1/2 inch liquid nitrogen fill port and start the liquid nitrogen transfer.

2.13 Monitor liquid nitrogen usage.

2.14 Vent the evolved nitrogen gas through the relief valves.

2.15 Monitor the 80°K shield temperature. This is done by measuring sensor resistance using a Hewlett-Packard Model 3490 Digital Multimeter in the four-wire mode. (Reference the Temperature Sensor Conversion Chart, Appendix #4).

<u>CAUTION</u>: The 80°K shield temperature must never exceed the magnet coil temperatures or the 30°K shield temperature by more than 40°K during cooldown to 77°K, to avoid inducing thermal stresses in the support rods.

<u>**30°K Shield Cooldown**</u>

2.16 Remove the helium stack vent flowmeter assembly to allow an escape port for venting gas.

2.17 Remove the 30°K vent flowmeter. Attach a liquid nitrogen line to the 1/4 inch OD 30°K vent tube using Swagelok fittings.

2.18 Transfer liquid nitrogen through the 30°K vent line. Pressurization of the liquid nitrogen supply with dry nitrogen gas will speed the cooldown of the 30°K shield. Pressure must be less than 60 psig.

2.19 Monitor both 30°K shield temperature sensors every 30 minutes. Record the temperature of the 80°K and 30°K shield. Refer to the cryostat shematic and temperature sensor conversion chart.

Magnet Space Cooldown

2.20 Install the liquid nitrogen fill/purge accessory into the liquid helium fill port. Engage the screw threads at the bottom of the tube into the threaded funnel inside the cryostat magnet space.

2.21 Attach the liquid nitrogen transfer line to the liquid nitrogen fill/purge accessory using a 3/8 inch OD tube.

2.22 Transfer liquid nitrogen into the magnet space.

CAUTION: The 30°K and 80°K shield temperatures must never exceed the magnet coil temperatures by more than 40°K until 100°K shield temperatures are reached. If the magnet coils begin to cool too fast, the liquid nitrogen transfer rate into the magnet space must be decreased or stopped to avoid inducing thermal stresses in the support rods.

2.23 Measure the coil resistance at the 41-pin instrumentation connection on the cryostat. Use a Hewlett-Packard Model 3468A Digital Multimeter in the 4-wire mode. Connect the sense leads to pins e and a. The nominal resistance at room temperature is approximately 145 Ohms.

2.24 Monitor the coil resistance every 15 minutes and determine the coil temperature using the resistance ratio vs temperature chart (Figure 3-2).

2.25 Continue liquid nitrogen transfer through the 30°K shield and into the magnet space until the 30°K and 4.2°K chamber temperatures no longer decrease with the addition of liquid nitrogen. Discontinue liquid nitrogen transfer into the magnet space (4.2°K chamber) when its temperature stabilizes. It is not necessary to "fill" the magnet space with liquid nitrogen. Continue liquid nitrogen transfer into the liquid nitrogen tanks until they are full (as indicated by the nitrogen level sensor or by liquid exiting at the nitrogen relief valves).

CAUTION: No port on the nitrogen tanks, magnet space, or 30°K vent line should be left open without a positive gas flow outward through the port. Otherwise, cryopumping of air/moisture will occur, clogging lines with frozen air/ice.

2.26 Measure and record 77°K electricals.

Section 3. Cooling to 4.2°K from 77°K

This cooldown sequence is to be carried out directly after the cooldown to 77°K.

3.1 Verify the cryostat insulating vacuum (Ref. Section 3.5.1).

Removing Liquid Nitrogen from the Magnet Space

3.2 Reinstall 30°K vent line flowmeter and close valve.

3.3 Connect dry nitrogen gas line to the He vent tee.

3.4 Connect a line from the liquid nitrogen purge line accessory to an empty line nitrogen storage vessel.

3.5 Using the regulator on the nitrogen gas line, pressurize the magnet space to 3-4 psig. This will force the liquid nitrogen in the magnet out through the liquid nitrogen purge line into the liquid nitrogen storage vessels. If the magnet space pressure exceeds approximately 5 psig, the safety valve will open. Pressure should be kept below approximately 5 psig.

Purging the Magnet Space with Nitrogen

3.6 Once liquid nitrogen is blown out of the magnet space, remove the liquid nitrogen lines to the storage vessel and purge the magnet space with nitrogen gas for a minimum of 8 hours.

3.7 Remove the nitrogen gas line from the He vent tee and connect it to the liquid nitrogen fill/purge line accessory.

3.8 Purge with nitrogen gas into the liquid nitrogen fill/purge line accessory and out of the He vent port for a minimum of 5 minutes.

3.9 Open 30°K vent line flowmeter valve and purge through flowmeter for a minimum of 5 minutes. Close the valve.

WARNING: No port on the nitrogen tanks, magnet space, or 30°K vent line should be left open without a positive gas flow outward through the port. Otherwise, cryopumping of air/moisture will occur, clogging lines with frozen air/ice.

Evacuating the Magnet Space

3.10 Remove liquid nitrogen fill/purge line accessory from the helium fill port (tube unscrews and may then be withdrawn) and plug the port.

3.11 Connect vacuum pump to the helium vent tee. (Ref. Section 3.1.1.2)

3.12 Insure all connections on the helium space are closed or capped and fittings are tight.

3.13 Begin evacuating the magnet space and continue to monitor coil temperature. If a rapid drop in coil temperature occurs, it means that there is still liquid nitrogen in the magnet space. If this happens, the pumping must be stopped and the magnet back-filled with dry helium gas and sequences 3.1.2.2 to 3.1.2.3 repeated. Do not pump to less than 150 torr absolute pressure (20 inches Hg of vacuum) in as indicated on the vacuum/pressure gauge if liquid nitrogen remains in the magnet. When it is possible to pump on the magnet space without a drop in temperature, continue pumping until a vacuum of 500 millitorr is reached.

3.14 Backfill the magnet space with dry helium gas to atmospheric pressure (0 psig).

3.15 Repeat the pumpdown to 500 millitor and backfill with dry helium gas a minimum of two times to insure removal of liquid nitrogen.

NOTE: Liquid Helium Level Monitoring

Liquid helium must be maintained in the cryostat to keep the windings superconductive. Five (5) liquid helium level probes are installed in the cryostat to monitor the level of liquid helium. The probes are connected to an IGC helium level indicator and a helium level sensor "Selector Switch". By rotating the selector switch, the level of helium on each probe may be checked.

One probe is located at the bottom of the magnet. This probe is used to indicate when helium begins to collect in the cryostat during initial fill. A similar probe is located at the top of the helium container to indicate when the magnet space is full. Two (2) probes, a primary and backup, are located at the midplane of the magnet. The fifth probe is located at the upper side of the magnet to indicate the helium level between the midplane probes and the top probe (Ref. Figure 3-3).

Generally, one of the midplane probes is monitored at all times to assure the level of liquid helium. This level must be greater than 50% on the midplane probe for safe operation of the magnet. A re-transfer of liquid helium is recommended prior to an indicated level of 60% on a midplane probe.

Initial Liquid Helium Transfer

The transfer of liquid helium from a storage vessel to the cryostat requires two (2) persons. It is important that the persons involved with the transfer be COMPLETELY FAMILIAR WITH THE EQUIPMENT AND THE PROCEDURE before attempting any liquid helium transfer. Before adding liquid helium to the cryostat, review the safety precautions for handling cryogens discussed in appendix 6.

CAUTION: Throughout the process, be sure there is always positive pressure in the magnet cryostat so that air is not pulled into the magnet.

3.16 Install the liquid nitrogen fill/purge line accessory in the helium fill port and screw it into position. This accessory is used only for liquid nitrogen fill/purge and the INITIAL fill of liquid helium (Ref. Dwg. E9677-100).

CAUTION: Insure the shim power lead is "fully" retracted or "fully" engaged. When fully retracted, the shim lead will bottom out on the shim guide tube and a black band may be seen above the compression nut. At all times, the shim power lead must be retracted as described or completely engaged at the bottom of the stack. Any other position of the shim lead will block the vent area in the neck and cause higher pressures during a quency or vacuum loss accident.

3.17 Place a 3/8 inch compression nut, ring and "O" ring on the short leg of the transfer line.

3.18 Position the liquid helium storage vessel so that the liquid helium transfer line will insert into both the magnet cryostat and the storage vessel.

3.19 Position the helium gas cylinder and regulator for use in pressurizing the liquid helium storage vessel.

3.20 Purge the liquid helium transfer line for one minute using gaseous helium.

3.21 With one person holding the long leg of the tranfer line and the other person holding the short leg, position the purged transfer line above the storage vessel and the fill port. Loosen, but do not remove, the 3/8 inch compression nut with plug, ring and "O" ring on the liquid nitrogen fill/purge line.

3.22 Insert the long leg of the transfer line into the storage vessel. Open the storage vessel valve and slowly insert the transfer line. This step provides additional purging and precools the transfer line.

3.23 Once COLD helium is exiting the short leg of the transfer line (as determined by a "Jet" of vapor):

- Immediately remove the fill port cap (previously loosened)
- Remove the gauge/flowmeter cap from the vent port
- Insert the short leg of the transfer line into the fill/purge line accessory (Ref. Dwg. C9651-218).
- Secure the compression nut, ring and "O" ring to seal the transfer line and fill tube connection (Ref. Dwg. E9677-100).

3.24 Adjust the position of the SHORT leg of the transfer line:

- Loosen the compression nut slightly
- Slide the transfer line in until it "bottoms"
- Lift the transfer line approximately 1/4 inch
- Retighten the compression unit

3.25 Adjust the position of the LONG leg of the transfer line in the storage vessel to a point approximately 1/2 inch from the bottom to the vessel. Check the storage vessel transfer tube seal.

3.26 Remove the cap on the 1 1/2" Ladish tee (Ref. Dwg. E9677-100). Vent gases outside.

3.27 Pressurize the storage vessel with helium gas to approximately 1 psi for five minutes. Thereafter, the transfer pressure may be increased to 3 psi.

3.28 When the top helium level probe shows 100%, turn off the helium gas to the supply dewar and vent the pressure in the supply dewar to atmospheric pressure (0 psig, as indicated on the supply dewar pressure gauge).

3.29 Open the valve on the refill transfer tube and quickly replace the cap and flowmeter on the helium space vent port. Open the stack flowmeter to allow gaseous helium boil-off to vent.

3.30 Remove the short end of the transfer tube from the refill tube and replace the 3/8 inch compression nut, ring, "O" ring and plug in the refill tube top.

3.31 Remove the 30°K vent flowmeter and attach a 1/2 psig check valve or a 1/4" urethane vent line. Close the stack vent flowmeter and allow all boil-off to exit through the urethane line until the 30°K shield temperature is approximately 30°K. Then replace the 30°K vent flowmeter.

3.32 Balance the boil-off flow by adjusting the flowmeters on the 30°K shield and the helium space stack vent. Flowmeters should indicate approximately equal flow.

3.33 After the magnet has been cooled to liquid helium temperature (4.2°K) and the temperatures have stabilized, proper levels of liquid helium and nitrogen must be maintained in the magnet. Replenishment of cryogens on a periodic basis is necessary to compensate for normal boil-off.

3.34 Measure and record 42°K electricals.

3.35 Measure and record helium boil-off rate.

Section 4. Magnet Startup

4.1 See that all magnet control cables are properly attached.

CAUTION: All cables should be connected per drawing listed in Appendix A. All instrumentation connectors located on the cable ends are locked securely onto the mating connector located on the cryostat by lining up the grooves with the ridges of the mating connector and sliding the connectors together. At the same time, rotate the bayonet-style locking ring until the connection is secure and the locking ring is snapped in place.

CAUTION: Never disconnect the 41-pin connector located on top of the cryostat header while the magnet is energized (in persistent or powdered mode).

The operation of the magnet protection circuitry depends upon the 41-pin connector being attached at all times. A sound alert is activated when the connector is disconnected.

Attach the High Current Leads

Retractable main and shim current leads are used to assure low liquid helium consumption and field stability. When the magnet is operated in persistent mode, the leads are electrically and thermally disconnected from the coils. The leads should not be retracted before the main coil persistent current switch is switched off.

The retractable high current leads must remain connected to the magnet and the IGC power supply for operation at currents between 1 Amp and 30 Amps.

Although redundant protection schemes are used in this system, correct operating procedures should be observed.

To ensure absolute safety, electrical quality rubber gloves should be worn when handling main coil high current leads, even though protection within the magnet has been provided. This protection limits the maximum terminal voltage across the leads to less than 22 volts.

4.2 Set the power supply for lead connection:

Breaker Switch: ON
Transient Suppression Switch: OFF
Power Leads: Connected to the supply
Main PCS Heater: OFF

4.3 Loosen the fittings sealing the leads to the header plate.

4.4 Individually push each lead into the cryostat far enough to connect the room temperature power supply leads ONLY. DO NOT contact the mating connector in the dewar at this time.

4.5 Connect power supply leads to the retractable lead terminals.

4.6 Push the high current lead straight down into the mating pin located in the cryostat. After the lead makes initial contact with the pin, push the lead downward until the pin connection contact is tight (approximately 1").

4.7 Tighten the high current lead locking fitting to prevent air contamination of the magnet space.

4.8 Repeat this operation for the second high current lead.

4.9 Open the vapor cooling valves approximately 1/4 turn to vapor cool the leads. Insure there is flow through the 30 K and stack flowmeters. Closing the lead valves will increase the flow through the flowmeter. Opening the lead valves will decrease the flow through the flowmeter.

4.10 The connection is verified electrically during the "Pre-Ramp, Main Power Supply, Current Level Set" procedure. When the high current leads are being ramped, the lead voltage monitor is observed. If the DANGER light comes on, the lead must be ramped down and the insertion procedure repeated.

CAUTION: When the magnet has current in the coils the area around and under the helium vent line should be kept clear of personnel. The vent system has not been tested and its response to a magnet quench is not confirmed. A quency is possible during any current operation.

Prior to ramping the main coil, review the following sections of the manual:

- o Electrical Shock Hazards
- o Magnetic Force/Field Effects
- o Magnet Quench
- o Instrumentation Manuals

The magnet protection controller (quench detector) is interlocked to the main and shim power supplies. When either the main or the shim power supply is turned on, the two "Active" lights on the front panel of the protection unit will come ON. If this does not occur, DO NOT RAMP the magnet. When both supplies are off or a power failure occurs, the protection unit switches into the passive mode and the "Active" lights go OFF.

Work Area and Magnet, Pre-Ramp Check

4.11 Verify there is NO MAGNETIC MATERIAL near the magnet.

4.12 Verify the MAGNET PROTECTION SYSTEM is operational. (Four lights on protection box are "on" when shim power supply and/or main supply are "on".)

4.13 Verify the LIQUID HELIUM LEVEL is above 90% on the upper sensor.

Pre-Ramp, Main Power Supply Current Level Set

(Pre-ramping the leads is required to verify power lead connections, to verify proper operatin of the main PCS, and to power up the supply.)

4.14 Set main PCS Heater: OFF

4.15 Set power supply line circuit breaker: ON

4.16 Set power supply transient suppression switch: OFF

4.17 Turn the transient suppression switch "ON" and ramp high current leads to level set, at 5 minutes to full scale by putting power supply in ramp up mode. Observe lead voltage monitor during ramp. If the danger light comes on, ramp down and repeat installation of retractable high current leads.

4.18 Set "Level Set" to 5000 Gauss as described in the Main Power Supply Manual.

4.19 Ramp high current leads to level set, at 5 minutes to full scale by putting power supply in ramp up mode. Observe lead voltage monitor during ramp. If the danger light comes on, ramp down and repeat installation of retractable high current leads.

4.20 Fine adjustment of the power supply current may be made by using the "Fine" level set dial. Once set, record and do not change the current level. (A more precise value of the current may be obtained by measuring the voltage across the power supply shunt. Ref. Power Supply Manual for value).

4.21 Main PCS Heater: ON
(Z2, Z4, Z6 PCS heaters ON, all other OFF)

4.22 Transient Suppression Switch: ON

4.23 Main Power Supply: Ramp UP Mode

4.24 Ramp Rate: (250 mfs)

4.25 Observe lead voltage monitor during ramp. If the danger light comes on, ramp down and repeat installation of retractable high current leads.

4.26 Monitor the main power supply output voltage. If the main power supply output voltage exceeds 4 volts, reduce the ramp rate by turning the vernier knob located on the power supply ramp rate selector switch counter-clockwise.

4.27 Record the level set and current.

4.28 The main coil will automatically come into level as adjusted in 4.18 above.

4.29 Once the main coil is ramped to the desired "level set", wait 10 minutes, turn off the main and shim PCS heaters, wait 10 seconds and switch the power supply to HOLD.

4.30 Verify the magnetic field is 5000 Gauss by measuring field with the portable Gauss meter.

4.31 Measure and record magnetic fields at locations away from the magnet. Map areas of 5 Gauss field.

4.32 Ramp the magnet to zero current.

Section 5. Measure Ramp Time

5.1 Starting at zero current, increase ramp speed slowly until protection circuit fires or until lead voltage reaches 8 volts. Record by strip chart recorder the lead voltage.

5.2 By repeated trial, find the maximum ramp rate that can be maintained without causing the protection circuits to fire.

5.3 Record the ramp rate and computed ramp time to 1.5 Tesla.

5.4 Ramp the magnet to 1.5 Tesla.

5.5 Measure helium boil-off rate with current leads in place.

5.6 Measure and record field stability.

5.7 Measure field in at least 20 locations. Is the magnet bore to confirm no change since the factory acceptance test.

5.8 Leave field 1.5 Tesla for quench test.

Section 6. Magnet Quench

6.1 Clear personnel from area around the magnet and around the vent line.

6.2 Barricade the area around the helium exhaust vent. Post an observer (and video camera if possible) to watch the exhaust.

6.3 Check that helium vent pressure gauge is zeroed properly.

6.4 Start data recorders and video recording of the magnet and vent line.

6.5 Initiate a quench manually.

6.6 After helium flow through the vent ceases, record maximum pressure reached on the helium vent.

6.7 Verify that the helium vent valve has re-started properly.

6.8 Check for any damage to the magnet or vent.

6.9 Re-cool to 4.2°K and fill helium to 100% level.

6.10 Repeat 4.2°K electrical measurements.

6.11 Check maximum ramp rate.

6.12 Ramp to 1.5 Tesla.

6.13 Measure helium boil-off rate with current leads in place.

6.14 Put magnet in persistant mode.

6.15 Remove current leads.

6.16 Measure helium boil-off rate.

6.17 Investigate any indication of significant change caused by the quench.

Section 7. Data Review

7.1 Check all data against the purchase specifications. Discuss and resolve any deviations from specifications.

Section 8. Assume Normal Operation

8.1 Ramp the current to zero.

8.2 Review and modify normal operating procedure as from test results.

8.3 Begin normal operation of magnet.

CRYOGEN HANDLING

WARNING

ASPHYXIANT/EXTREME COLD/STRONG MAGNETIC FIELD

NITROGEN (N_2) AND HELIUM (He) PRESENT IN LIQUID AND GASEOUS FORM

POWERFUL MAGNETIC FIELD PRESENT

PERSONS WEARING ELECTRONIC MEDICAL DEVICES SHOULD STAY CLEAR OF AREA.

NITROGEN OR HELIUM GAS reduce oxygen available for breathing in confined, poorly-ventilated areas.

Nitrogen and helium are inert, odorless, colorless and tasteless gases.

MAY CAUSE UNCONSCIOUSNESS OR DEATH WITHOUT WARNING.

Use in well-ventilated areas. Do not vent magnet in confined space.

LIQUID NITROGEN OR LIQUID HELIUM are extremely cold and the liquid or cold gas from the liquid can cause severe frostbite to the eyes and skin. Do not touch frosted pipes or valves.

STRONG MAGNETIC FIELD HAZARD - magnetic objects such as iron tools, parts and tanks may be pulled toward magnet by strong magnetic field present. Injury to personnel and damage to equipment may result. Keep all magnetic material more than 20 feet away. Personal electronic medical devices may be affected by strong magnetic field.

INTERMAGNETICS GENERAL CORPORATION
GUILDERLAND, NEW YORK, USA
TEL. (518) 456-5456

SECTION 2
SAFETY

2.0 INTRODUCTION

The cryomagnetic system has been designed to be safe when used according to recommended practices and procedures. This section describes items relevant to human and system safety. The safety concerns are classified into three main categories.

2.1 Safety Precautions in Handling Cryogens
2.2 Electrical Shock Hazards
2.3 Magnetic Force/Field Effects

2.1 SAFETY PRECAUTIONS IN HANDLING CRYOGENS

The basic precautions described in this section apply equally to the handling of liquid nitrogen and liquid helium. For a further discussion on cryogen handling, refer to Appendix C, "Recommended Safety Precautions for Handling Cryogenic Liquids," by the Cryogenic Society of America.

The potential hazards in handling helium stem mainly from four important properties of liquid helium:

1. The liquid is extremely cold.
2. Liquid helium will condense and solidify air.
3. Small amounts of liquid produce large volumes of gas.
4. Helium is NON-LIFE-SUPPORTING.

2.1.1 Cryogen Contact with Eyes and Skin

Protect eyes and cover skin where the possibility of contact with cold fluid exists. Accidental contact of liquid helium or cold helium gas with skin or eyes may cause a freezing injury similar to a burn.

2.1.2 Ventilation of Work and Storage Spaces

Although helium is non-toxic, it can cause asphyxiation in a confined area. Since helium is colorless, odorless, and tasteless, it cannot be detected by the human senses and may be inhaled normally like air. The cloudy vapor that appears when liquid helium is exposed to the air is condensed moisture, not the gas itself. Unless adequately ventilated, the expanding volume of helium will displace normal air without warning that a non-life-supporting atmosphere is present. (See Section 4.5 for vent recommendations.)

FIRST AID NOTICE:

If a person becomes groggy or loses consciousness when working with liquid helium, move him to a well-ventilated area immediately. If breathing has stopped, apply artificial respiration. Always consult a physician.

2.1.3 Liquid Helium Effects on Air and Other Gases

The low temperature of liquid helium or cold gaseous helium can solidify other gases. If allowed to form and collect, solidified gases and liquids, particularly solidified air, may plug pressure-relief passages and foul relief valves. Plugged passages are hazardous due to the excess pressure produced as heat leaks into gas-tight vessels containing liquid helium.

1. Always store and transfer liquid helium under positive pressure and in closed systems to prevent cryogen contamination.

2. Do not permit condensed air on transfer dip tubes to run down into the container opening.

3. Keep pressure-relief devices free and clear.

2.1.4 Pressure-Relief Devices

Liquid helium has a very low latent heat of vaporization. It evaporates very rapidly when heat is introduced or when liquid helium is transferred into warm or partially-cooled containers. Pressure-relief devices for liquid helium equipment must be of adequate capacity to release helium vapor resulting from heat inputs. (See Section 4.5 for vent recommendations.)

2.1.4.1 Cryogen Relief Devices

The cryogen chambers for liquid nitrogen and liquid helium in the SCM100-15 system have been provided with pressure-relief devices. The liquid nitrogen reservoir has two relief valve assemblies that will maintain positive pressure and keep moisture out of the chamber. The liquid helium reservoir has one relief valve. Both liquid helium and liquid nitrogen chambers are fitted with "over-pressure" burst disks.

As described (2.1.1-2.1.5), vented cryogens may cause danger. It is recommended that the cryostat vents and burst disk be connected to a larger exit pipe in order to safely carry cold vapors and liquids away from the work space. Detailed requirements for sizing the exit piping are presented in Section 4.5.

2.1.4.2 Vacuum Space Relief Device

The vacuum space is equipped with a burst disk to prevent the accumulation of a hazardous pressure in the vacuum space in the event of a "loss of vacuum" accident.

2.2 ELECTRICAL SHOCK HAZARDS

The fundamental hazard to be avoided in the use of this system is high voltage. A second hazard is the effect of induced eddy currents.

2.2.1 High Voltage Protection

Although redundant protection schemes are used in this system, correct operating procedures should be observed.

To ensure absolute safety, electrical quality rubber gloves should be worn when handling main coil high current leads, even though protection within the magnet has been provided. This protection limits the maximum terminal voltage across the leads to less than 22 volts.

2.2.2 Retractable Lead Hazards

Retractable main and shim current leads are used to assure low liquid helium consumption and field stability. When the magnet is operated in persistent mode, the leads are electrically and thermally disconnected from the coils.

The leads should not be retracted before the main coil persistent current switch is switched off (Ref. Section 3.2).

MAGNET SAFETY

2.3 MAGNETIC FORCE/FIELD EFFECTS

Concerns relevant to the environmental effects of the magnetic fields generated by operation of the system have been divided into two basic groupings: Effects on Inanimate Metallic Objects and the Physiological Effects on Operators and Patients.

2.3.1 Magnetic Field and Force Effects on Metallic Objects

The magnetic field beyond the cryostat is very strong. The field will attract ferrous objects toward the magnet and may affect the performance of electronic equipment in the area. Figure 2-2 shows the isofield lines about the magnet system.

The attraction of metal objects to the magnet can be dangerous. Some worst case conditions relating distance from the magnet to G's of force have been plotted in Figure 2-1. The force plot should be used as a guide to labeling and positioning equipment that must be used near the magnet.

Danger to humans due to the attraction of metal objects may occur in two ways:

1. An operator may be pinned between the cryostat by a large metal object such as a nitrogen can.
2. A person within or near the bore of the magnet could be struck by an object flying into the bore.

For these reasons, IGC recommends the proper training of all operators and the installation of a protective shield over one end of the bore. A non-magnetic aluminum or epoxy-fiberglass composite plate, approximately one-inch thick and mounted at one end, is an effective, inexpensive means of improving the safety of magnet operation.

2.3.2 Magnetic Field Effects on Human Subjects

IGC distinguishes between two levels of human exposure associated with operation of NMR cryomagnetic systems:

1. Extended, moderate exposure to the operating staff.
2. Temporary, high field exposure to the patient.

As manufacturer, IGC is concerned for human safety during system use but does not act as advisor to the patient on exposure conditions. The bibliography of the paper by Budinger in Appendix B may be used as a starting point for a customer study to establish policy and procedures regarding human exposure to magnetic fields.

2.4 EMERGENCY MAGNET DE-ENERGIZATION

The magnet system is provided with an emergency field dump system. To activate, a contact closure circuit, designed and installed in the customer facility by the customer, should be wired to the plug at connector 1 J5 in the side of the cabinet assembly (Dwg. D940956). Closure of the contact circuit will quench the magnet and rapidly de-energize the magnet.

CAUTION

THE EMERGENCY FIELD DUMP SHOULD NOT BE USED TO DE-ENERGIZE THE MAGNET UNDER OTHER THAN EXTREME EMERGENCIES.

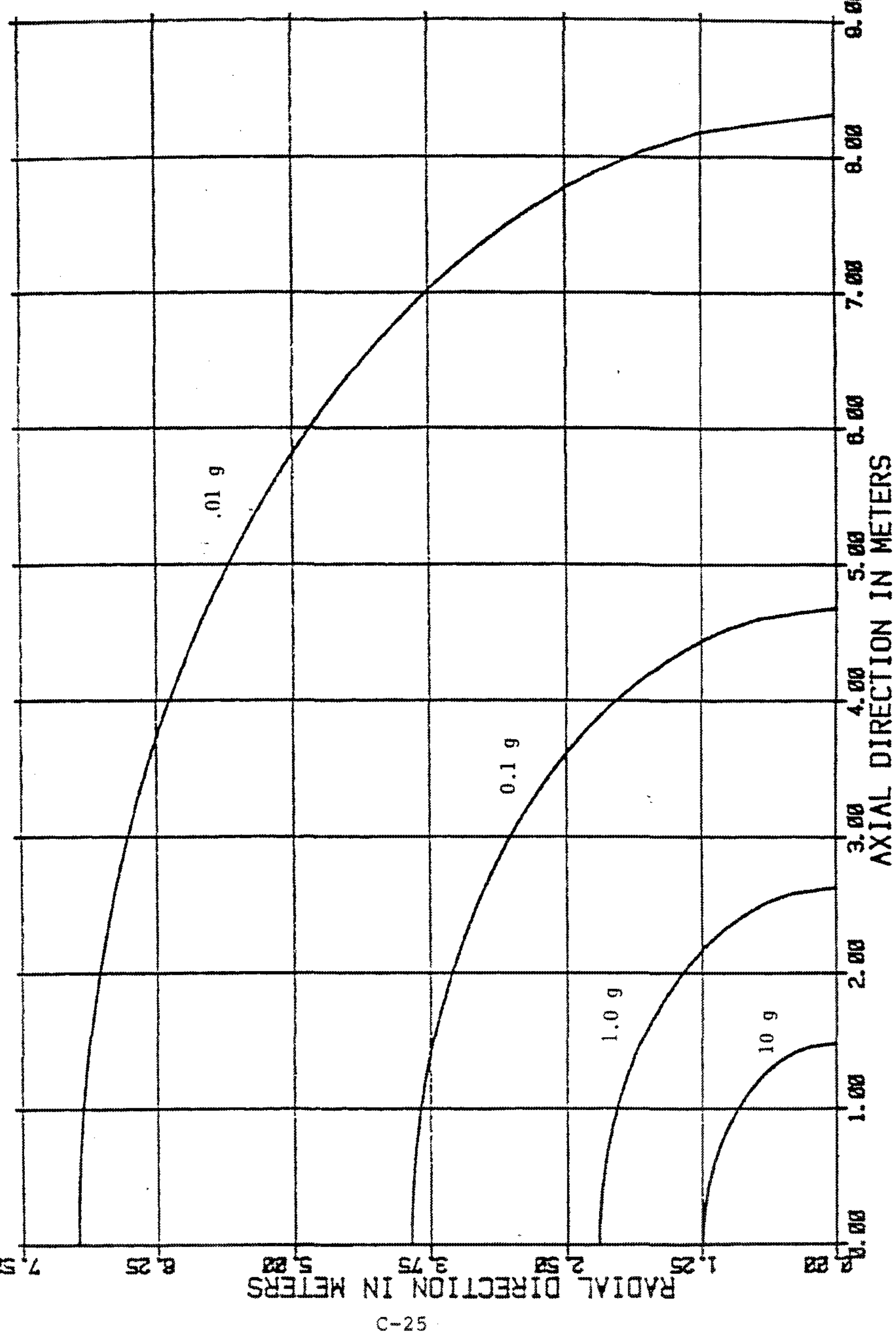
A complete description of the emergency dump system and requirements for the contact closure is contained in the Instrumentation Manual.

2.5 DC EMERGENCY POWER SUPPLY

Loss of facility AC power during ramping or shimming can leave the magnet in an unprotected mode. To compensate for this, provision has been made for the customer to connect a 12-volt DC supply through connector 1 J5 (Dwg. 940956). This supply will provide necessary power to protect the magnet. The circuit and supply requirements are described more fully in the Instrumentation Manual.

FIGURE 2-1

ISOFORCE PLOT



PROCEDURE PSP-1
CALIBRATION OF RELIEF VALVE TEST GAGE

Purpose:

Annual testing of relief valves on the PSP cryostats requires a gage to indicate gas pressure when the relief valves open. This procedure is to calibrate the required dial pressure gage for use in relief valve tests.

Equipment Required:

- o Dial pressure gage, 0-30 PSIG
- o 15 PSIG air piston gage primary presure standard
- o clean air or inert gas supply at 20 PSIG

Procedure:

1. Adjust the dial pointer on the pressure gage to read zero when the gage is open to room air.
2. Connect the air piston gage to the pressure gage and to the gas supply line.
3. Set weights on the air piston as required by the operating manual to obtain 15.00 PSIG standard pressure.
4. Open the gas supply valve and slowly bleed gas to raise pressure enough to lift the air piston to the upper stop.
5. Press the piston rotation switch to start the air piston rotating. Repeat as necessary to keep the piston rotating.
6. When the air piston drops away from the upper stop and is floating, record the reading shown by the pressure gage. If indicated pressure deviates more than 1.5 PSI from 15 PSIG, replace the gage.
7. Record the pressure reading on a tag and attach it to the gage. This reading is the upper reference for calibrating relief valves on the PSP cryostat.

Approved By: WM Taylor
Research Manager

8/25/83
Date Reviewed

Date Approved: 8/25/83

Custodian: [signature]

PROCEDURE PSP-2
TESTING CRYOSTAT PRESSURE RELIEF VALVES

Purpose:

Pressure relief valves provide back-up gas venting from liquid helium and liquid nitrogen volumes in the PSP superconducting magnet. To insure proper operation of these relief valves, an annual test will be done to determine if the relief valves open at less than 15 PSIG.

Equipment Required:

- o Calibrated 15 PSI pressure gage.
- o Test fixture to attach gage and shut-off valve to vent lines.
- o Helium cylinder and pressure regulator set at 15 PSIG.
- o PSP superconducting magnet.

Helium Relief Valve Test:

1. Install leads to the magnet coil and reduce coil current to zero. This reduces the magnetic field to zero and removes stored energy from the cryostat.

2. Read and record helium vapor flow rate indicated by the helium flow meter.

3. Attach the calibrated pressure gage to the test fixture and open the exhaust valve on the fixture.

4. Attach the test fixture to the exhaust of the helium flow meter and to a 1/4 inch copper tube to the helium pressure regulator.

5. Close the exhaust valve on the test fixture and open the valve to the helium supply.

6. Watch the pressure gage and verify that pressure stabilizes below 15 PSIG, thus indicating proper operation of the relief valve. If pressure reaches 15 PSIG, open the exhaust valve, close the helium supply valve and repair or replace the relief valve to obtain pressure relief at less than 15 PSIG.

7. Close the helium supply valve, Open the exhaust valve and bleed pressure to zero.

8. Remove the test fixture.

9. Wait eight hours and read the helium flow meter. Flow should match the reading in Step 2 within $\pm 20\%$. If flow is low the relief valve needs to be reseated to cause normal venting. The relief valve sould be shut off at 0 PSIG.

10. When flow is normal, the helium test is complete.

Nitrogen Relief Valve Test:

1. Open the exhaust valve on the test fixture.
2. Attach the fixture to the 1 inch copper tube connected to the nitrogen vent and to the helium cylinder regulator.
3. Close the exhaust valve and open the helium supply valve.
4. Watch the pressure gage and verify that pressure stabilizes below 15 PSIG, thus indicating proper operation of the relief valve. If pressure reaches 15 PSIG, open the exhaust valve, close the helium supply valve and repair or replace the relief valve to obtain pressure relief at less than 15 PSIG.
5. Close the helium supply valve, Open the exhaust valve and bleed pressure to zero.
6. Remove the test fixture.
7. The test is complete. Bag the test fixture in a clean polyethylene bag and store it for future use.

Approved By: WM Taylor
Research Manager

8/25/83
Date Reviewed

Date Approved: 8/25/83

Custodian: [signature]

PROCEDURE PSP-3

INSPECTION OF CRYOSTAT RUPTURE DISCS

Purpose:

Rupture discs on helium and nitrogen vents provide secondary back-up to the relief valves on the cryostat volumes. The discs are made to rupture at 23 PSIG. They are to be inspected annually to insure that they are undamaged and unobstructed.

Procedure:

1. Remove the helium vent pipe downstream from the helium rupture disc. Caution, do not remove the rupture disc. This will allow air to diffuse into the liquid helium cryostat where it would freeze and possibly cause malfunction of the cryostat or magnet.

2. Visually inspect the rupture disc for physical damage, corrosion, or blockage. If damage is found install a plastic liner around the disc flange, purge it with helium, remove and replace the rupture disc.

3. Replace the helium vent line.

4. Remove the vent line downstream from the nitrogen rupture disc.

5. Visually inspect the rupture disc for physical damage, corrosion or blockage. Replace the disc if necessary.

6. Replace the nitrogen vent line.

Approved By: W.M. Taylor
Research Manager

8/25/83
Date Reviewed

Date Approved: 8/25/83

Custodian: Dean Bridgman

APPENDIX D

CTM PROJECT AND SCOPE OF WORK

OSR 19-67A (Rev 3-79)

SRP COST ORDER

No. S-4182

JOB TITLE	BUILDING NUMBER & AREA	PROBLEM NO.
COMPONENTS TEST MODULE FOR PSP FACILITIES	773-A	11-4037

WORK REQUESTED BY	DATE	WORK COMPLETION DATE REQUIRED	DIRECT COST	INDIRECT OPER COST	INDIRECT EXPMT'L	SUSPENSE	TEMP	ACCOUNT CODE
K. Andringa	6-13-84	7/85			X			8581-1P

WORK DESCRIPTION

GE-03-47-01-0

Provide labor and material for the installation of the Components Test Module (CTM) in Building 773-A for the Plasma Separation Process. This work is developmental and is to be charged to cost in FY-1984 and FY-1985.

EXPENDITURE SCHEDULE

FY-1984	$1,500,000
FY-1985	$1,500,000
Total	$3,000,000

COST ESTIMATE

Design	$ 400,000
Equipment & Installation	$2,600,000
Total SRL Cost	$3,000,000

THIS WORK ASSIGNED TO ENGINEERING DEPARTMENT CONSTRUCTION DIVISION AS ASSIGNED MAINTENANCE ORDER NO. ____________

DAVIS-BACON ACT APPLIES: [X] YES – PAR C-7 [ ] NO – PAR ____

REVIEWED BY (INITIALS): JDH

EFFECT ON PROCESS — CLASSIFIED BY (INITIALS): WEC

[X] CLASS I [ ] CLASS II [ ] CLASS III (NO EFFECT) (WORKS TECHNICAL APPROVAL REQD)

GREEN WORK REQUEST NO.

PREPARED BY: J. D. Herrington (signature) DATE 6-13-

WORK ASSIGNED TO: [X] CONSTRUCTION [ ] WORKS ENGINEERING [ ]

EQUIPMENT PIECE NUMBER

CONTRACT GROUP: [ ] E & I [ ] MAINT [ ] T & T [X] SRL [ ] EED

CRITICALITY POTENTIAL: [ ] YES [X] NO BY WEC (INITIALS) (FOR WORKS TECHNICAL ONLY)

IDP NUMBER

DRAWING REVISION REQUIRED: [X] YES [ ] NO

ESTIMATE				T & T	AREA MAINT	717-A MAINT	TOTAL MAINT	AREA E & I	722-A E & I	TOTAL E & I	TOTAL HOURS	TOTAL DOLLARS
MAN-HOURS												
MATERIAL												
ESTIMATED BY											GRAND TOTAL	3,000,000

APPROVALS – SAVANNAH RIVER PLANT

(a) ______________________ DATE

(b) DEPT SUPERINTENDENT ______________________ DATE

(c) GENERAL SUPERINTENDENT ______________________ DATE

(d) PLANT MANAGER OR ASST PLANT MANAGER ______________________ DATE

APPROVALS – WILMINGTON

______________________ DATE

______________________ DATE

______________________ DATE

APPROVALS – DOE

______________________ DATE

GENERAL INFORMATION

PROJECT NO. S-4182 - SAVANNAH RIVER LABORATORY

REVIEW OF PRESENT CONDITIONS

At the request of the Department of Energy (DOE), Savannah River Laboratory (SRL) and the Engineering Department are currently performing the conceptual designs and cost estimates for a Fuel Improvement Demonstration Facility (FIDF) to be located at Savannah River Plant. The FIDF employs the Plasma Separation Process (PSP), developed by the TRW company with DOE funding, to remove the undersirable uranium - 236 isotope from the highly enriched uranium stockpile. The target start-up date for this demonstration facility is FY-1988. In order to support the design and timely start-up of this facility SRL has defined a development program of which the Components Test Module (CTM) is a vital part.

Although TRW has demonstrated the process physics and continues to be funded by DOE for further process development, no facility exists in the overall program where prototype process hardware can be tested at full process power levels and for extended operating times. The CTM will be able to test full size source assemblies and product collectors at process power dissipations using depleted uranium only. Resulting design modifications will be implemented in the demonstration facility.

REVIEW OF PRESENT CONDITIONS (Continued)

In addition, the handling of process hardware covered with uranium films will be demonstrated in the CTM installation prior to implementation in the FIDF. At a later time the CTM will be available as a test bed for further design modifications and process improvements.

This cost funded project proposes to provide funds for the installation of the CTM in Section D of Building 773-A.

DESCRIPTION OF PROPOSED WORK

Provide labor and material for the installation of a CTM for the PSP program. The equipment will consist of the following major components.

- 2500 KVA Substaion
- Cooling Tower, pumps and support equipment
- Liquid & Gaseous Nitrogen Supply System
- Power Supply Building & Equipment
- Motor Control Centers
- Vacuum System
- Plate Heat Exchangers
- Deionized Water System
- Miscellaneous piping and work platforms
- Containment Facilities

GENERAL INFORMATION

PROJECT NO. S-4182 - SAVANNAH RIVER LABORATORY

REMARKS

The Savannah River Laboratory has full responsibility for this project.

The work proposed by this project will be accomplished by the Construction Division of the Engineering Department, E. I. duPont de Nemours & Co., and/or its subcontractors.

Tests of the CTM, for the PSP program, are expected to be complete in less than three years after installation.

OSR 8-125.2
(Rev 9-69)

SUMMARY ESTIMATE OF TOTAL COST

PROJECT NO. S-4182 - SAVANNAH RIVER PLANT

Title COMPONENTS TEST MODULE FOR PSP FACILITIES, BUILDING 773-A

Date June 13, 1984 Estimator K. J. Bryan Engineer K. J. Bryan

	DOLLARS IN THOUSANDS LABOR	MATERIAL	ITEM	TOTAL
1. Engineering Design and Inspection at 15.4% of Construction Costs				400
a. Design ED-2			310	
b. EC-1			75	
c. ECD			15	
2. Construction Costs				2600
a. Buildings			165.7	
(1) Building 773-50A, 1450 SF - Contract	--	115.5		
(2) Control Room and related modifications to Building 773-A.	30.2	20.0		
b. Special Facilities			2,066.7	
(1) Equipment foundations and platforms	78.7	9.9		
(2) Cooling Tower, plus associated equipment, piping and electrical	100.7	144.2		
(3) Deionized water cooling system, plus associated equipment, piping and electrical	55.9	112.1		
(4) Process Piping	216.6	151.2		
(5) Electrical and Instrumentation	14.9	445.2		
(6) Control room consoles, magnet power supplies and instrumentation	16.4	--		
(7) Install and align PSP magnet, Transporters, Source & Collector End Assemblies, plus assoc equip.	93.1	4.9		
(8) Paging, fire and security systems	46.2	24.9		
(9) Vacuum System	69.7	270.4		
(10) Alpha constant air monitors & assoc. equip.	27.3	68.0		
(11) Gyrotron associated equipment	50.8	1.4		
(12) Containment enclosures and HEPA filtered exhaust system	32.1	32.1		
c. Utilities			367.6	
(1) 90Kv & 4Kv Power supply systems Building 773-50A	30.5	1.8		
(2) 2500 KVA substation and motor control center	143.2	158.6		
(3) Lighting and receptacles	24.1	9.4		
Construction Costs Subtotal	1030.4	1569.6		
Subtotal				$3,000.0
3. Total Project Estimate				$3,000.0

(Subdivision 5)

ADDENDUM

PROJECT NO. S-4182 - SAVANNAH RIVER LABORATORY

A. SAFETY HAZARDS AND ENVIRONMENTAL CONSEQUENCES

A Process Hazards Review for the Venture Guidance Appraisal preparation will be completed, however no significant findings are anticipated. The environmental consequences due to operation of the CTM have been addresed under the guidelines of the National Environmental Policy Act (NEPA) and are insignificant.

No new safety hazards are expected. Environmentally, all State and NEPA requirements will be met and the operation of the CTM will cause no significant adverse environmental impact on or offsite.

B. PROJECT PLAN

Assumed Authorization Date: July, 1984

	Start	Complete
Conceptual Design	Complete	
Engineering Design	In Progress*	7 MAA
Procurement	In Progress*	9 MAA
Construction	Upon Authorization	12 MAA

*$350,000 advance funds for procurement and design.

Scope of Work
Plasma Separations Process, 773-A, Fab Lab
ES 0883120, Project S-4182

The following describes the work required to install the Plasma Separations Process (PSP) Components Test Module (CTM) in the Fab Lab, Building 773-A.

1) Install a concrete foundation per drawing ST5-23855.

2) Fabricate and install three (3) 11 gauge stainless steel containment pans. Two of the pans are to be located under the transporters and have approximate dimensions of 10 feet wide, 22 feet long, and 7 inches high. The third pan is to be located under the magnet and has approximate dimensions of 16 feet wide, 13 feet long and 7 inches high. The transporter pans are to have one side gasketed and removable.

3) Install and align PSP magnet on concrete foundation. Install and align bore tube in PSP magnet. Alignment is critical and is to be accomplished by optical alignment with shims and 'wejit' anchor bolts. The pre-installation survey and magnet installation procedure are described in document PSP-24P-298, 'CTM Sub-System Installation Alignment'. Construction layout will be requried for the optical alignment. TRW will provide coordination and technical assistance for this operation.

4) D & R Propane Shed, Building 773-3A. Entire structure is to be dismantled except for foundation and columns, which are to be cut 2 feet, 6 inches above finished concrete.

5) Relocate 13.8 KV transmission line underground as described in the following scope.

6) Install Cooling Tower

- Fabricate and Install an 8 inch W.F.I-Beam structure on existing columns of Building 773-3A (Dismantled Propane Shed).
- Install one (1) packaged Cooling Tower on I-Beam structure. The Vendor will provide factory supervision during installation.
- Excavate and pour a concrete pad 5 feet wide, 10 feet long and 1 foot high.
- Install two (2) Cooling Tower pumps, each with approximately 75 HP, 480 V, 3 phase motors.
- Install water treament system.
- Purchase and install approximately 290 feet of 8 inch schedule 80 CPVC pipe for cooling tower supply and return lines. Approximately 90 feet of the piping will have to be encased in concrete under the road between the cooling tower and the heat exchangers.
- Purchase and install approximately 25 feet of 1 inch schedule 80 CPVC pipe from the 1 inch process water line at the north east corner of the cooling tower foundation to the make up connection on the cooling tower.
- Purchase and install 15 feet of 2 inch schedule 80 CPVC pipe from the cooling tower overflow connection to the 2 inch underground storm sewer west of the cooling tower foundation.
- Purchase and install 5 feet of 1 inch schedule 80 CPVC pipe from the drain connection to the 2 inch CPVC pipe.
- Purchase and install 25 feet of 1 inch schedule 80 CPVC pipe from the Bleed-off point in the cooling water supply line to the 2 inch CPVC pipe.
- Purchase and install a filter unit in the cooling tower outlet line.
- Purchase and install associated valves and fittings.
- Purchase and install all required conduit and wiring to the cooling tower pumps and the 25Hp, 230/460V, 3 phase, TEFC cooling tower fan motor. Purchase and install pump control wiring to the control room.

7) Install Deionized Water Cooling System outside Fab Lab between columns 52 and 57.8 on existing concrete.
   - Install two (2) Plate Heat Exchangers.
   - Install a high pressure deionized water pump with an approximately 60 Hp; 480V; 3 phase motor.
   - Install a low pressure deionized water pump with an approximately 75 Hp; 480V; 3 phase motor.
   - Install a deionized water storage tank approximately 6 feet in diameter and 8 feet high.
   - Purchase and install 10 feet of 8 inch schedule 10 304L stainless steel pipe from the deionized water storage tank to the low pressure pump.
   - Purchase and install 5 feet of 4 inch schedule 10 304L stainless steel pipe from the 8 inch line ot the high pressure pump.
   - Purchase and install 10 feet of 6 inch schedule 10 304L stainless steel pipe from the low pressure pump to the low pressure heat exchanger.
   - Purchase and install associated valves, fittings and gages.
   - Purchase and install all required conduit and wiring to the two (2) deionized water pumps. Purchase and install all required conduit and control wiring from the pumps to the control room.

8) Purchase (by LSD) a pre-engineered building to serve as the Power Supply Building. The vendor will pour the slab and erect the building.

9) D & R old vault and renovate as a control room for PSP.
   - Remove over head crane.
   - Remove existing north wall and door in south wall.
   - Purchase and Install a window 23 feet long and 4 feet high between columns 57.8 and 61.8.
   - Purchase and Install a door in the south wall.
   - Purchase and Install a door in the east wall.
   - Purchase and Install a wall 5 feet north of the removed north wall.
   - Purchase and install lighting.
   - Purchase (by LSD) and install (by vendor) a Halon Fire Suppression System.

10) Purchase (by LSD) and Install (by Vendor) a 12 inch high raised floor, with air flow slots for air conditioning, in the control room.

11) Install consoles, magnet power supplies, and instrumentation in the control room. TRW will provide coordination and technhical assistance.

12) Fabricate and install a pipe/conduit rack along the mezzanine from the east wall of the high bay area to the magnet. (25 feet) Purchase and install an intercom system in the control room, magnet area, and Power Supply Building. Purchase and install 50 feet of 2 inch conduit from the control room to the magnet. Pull magnet control and instrumentation wiring in the conduit. Purchase and install 50 feet of 1 inch conduit from the control room to the magnet. Pull the magnet power supply cabling in the conduit. Connect all control, instrumentation, and power supply cabling at the magnet. TRW will provide coordination and technical assistance.

13) Purchase and install an overhead pipe/conduit rack from the heat exchangers to the mezzanine pipe/conduit rack. Purchase and install an overhead pipe/conduit rack from the mezzanine pipe/conduit rack to the gyrotron. Purchase and install an overhead pipe/conduit rack from the Power Supply Building to the heat exchanger pipe/conduit rack. (235 feet total)

<u>140 Psi Piping</u>

- Purchase and install 210 ft. of 4 inch schedule 10 304L stainless steel pipe from the high pressure heat exchanger to the gyrotron.
- Purchase and install 240 ft. of 4 inch schedule 10 304L stainless steel pipe from the gyrotron to the deionized water storage tank.
- Purchase and install all required valves, fittings, and gages.

<u>100 Psi Piping</u>

- Purchase and install 175 ft. of 6 inch schedule 10 304L stainless steel pipe from the low pressure heat exchanger to the north end of the magnet.
- Purchase and install 100 ft. of 6 inch schedule 10 304L stainless steel pipe from the 6 inch supply header to the Power Supply Building.

- Purchase and install 35 ft. of 3 inch schedule 10 304L stainless steel pipe from the 6 inch supply header to the gyrotron.

- Purchase and install 200 ft. of 6 inch schedule 10 304L stainless steel pipe from the north end of the magnet to the deionized water storage tank.

- Purchase and install 100 ft. of 6 inch schedule 10 304L stainless steel pipe from the Power Supply Building to the 6 inch return header.

- Purchase and install 35 ft. of 3 inch schedule 10 304L stainless steel pipe from the gyrotron to the 6 inch return header.

- Purchase and install all required valves, fittings and gages.

14) Install the 90 Kv and 4 Kv Power Supply Systems in the Power Supply Building. Seven (7) separate units are to be installed. Purchase and install 100 ft. of 3 inch schedule 10 304L stainless steel pipe from the units to the 6 inch Power Supply Building supply and return headers. Purchase and install all required valves, fittings, and gages. TRW will provide coordination and technical assistance.

15) Install a 2.5 MW substation, Motor Control Center, ground well, and ground bus as described in the following scopes.

16) Purchase and Install 230 feet of 3 inch conduit from the Power Supply Building to the gyrotron area. Pull two (2) RG 220 cables in the conduit and connect to the 90 Kv Power Supply. Purchase and install 200 ft. of 3 inch conduit from the Power Supply Building to the magnet. Pull the 4 Kv power supply cable and the current return cable in the conduit and connect to the 4 Kv power supply. Purchase and install six (6), 175 ft., 2 inch conduit runs from the Power Supply Building to the control room. Pull all control cabling in the conduits and make all connections to the units in the Power Supply Building and the consoles in the control room. TRW will provide coordination and technical assistance.

17) Install 55 ft. of Nitrogen Vent piping. The line runs from the magnet; eastward along the mezzanine pipe/conduit rack; through the outside wall of the Fab Lab; and upward; terminating 5 feet above the main roof.

18) Purchase and install 30 ft. of 3 inch schedule 10 304L stainless steel pipe from the 6 inch deionized water supply and return lines to the Bore Tube. Purchase and install all required valves, fittings, and gages.

19) Install the Vacuum Chamber, two (2) Diffusion Pumps, and two (2) Cold Traps. Purchase and install 50 ft. of 1/2 inch schedule 10 304L stainless steel pipe from the 6 inch deionized water supply and return lines to the Diffusion Pumps. Purchase and install all required valves, fittings, and gages. TRW will provide coordination and technical assistance.

20) Install 130 feet of 3/4 inch vacuum jacketed pipe from the Liquid Nitrogen tank in 773-A, 'C' courtyard to the magnet. Purchase and install 10 ft. of 3/4 inch copper tubing, insulated, from the Liquid Nitrogen Supply pipe to the magnet cryostack. Purchase and install 50 ft. of 3/4 inch copper tubing, insulated, from the Liquid Nitrogen Supply to the diffusion pump cold traps. Install all required controls, valves, fittings and gages. Purchase and install 150 feet of 3/4 inch schedule 40 carbon steel pipe from the vaporizer adjacent to the Liquid Nitrogen tank to the north end of the magnet. Purchase and install all required valves, fittings, and gages.

21) Install two (2) transporters, the Source End Assembly (SEA), and the Collector End Assembly (CEA). Align transporters and position locking pins. Bore four (4) holes through the containment pans and into the concrete. Fabricate and Install four (4) locking pin sockets. Fabricate and Install four (4) cantilevered deionized water headers on the magnet (two (2) on the CEA end of the magnet and two (2) on the SEA end of the magnet). Purchase and Install 20 ft. of 2 inch scheduel 10 304L stainless steel pipe from the deionized water supply and return lines to the cantilevered headers. Purchase and install all required valves, fittings, and gages. Install four (4) flexible tube bundles (one (1) on each cantilevered header). Connect flexible tube bundles to the SEA and CEA. TRW will provide coordination and technical assistance.

22) Purchase and install compressed air piping from the building air header to fifteen (15) solenoid operated valves.

23) Purchase and install Argon service piping from Argon supply to magnet.

24) Install the mechanical vacuum pumping system consisting of a Roughing Pump, a Holding Pump, and a Foreline Pump. Purchase and install all wiring and conduit required for electrical connections. Purchase and Install 200 ft. of 6 inch and 110 ft. of 2 inch schedule 10 304L stainless steel pipe from the nechanical vacuum pumps to the magnet vacuum chamber. Purchase and install required valves, fittings, and gages. Install vacuum system monitors and control instrumentation in the control room. Purchase and Install all required control cabling. Fabricate and install a noise attenuation enclosure around the mechanical vacuum pumps. TRW will provide coordination and technical assistance.

25) Install a HEPA filtered exhaust system from the mechanical vacuum pumps. Purchase and install all required piping, valves, and fittings.

26) Purchase and Install 100 ft. of 2 inch conduit from the control room to the gyrotron area. All of this run will be overhead. Install the Gyrotron tank, tube and support stand. Connect the 4 inch high pressure deionized water supply and return and the 3 inch low pressure deionized water supply and return. Install the gyrotron magnet power supplies. Install the Gyrotron Control Panel in the control room and all required control cabling to the gyrotron. Install the Alarm Center Interlock Panel in the control room and all required cabling. Connect the 90 Kv power supply cable. Install the Fluorocarbon (FC) Cart. TRW will provide coordination and technical assistance.

27) Install and align the waveguide strongback. Install and align the waveguide. Connect to the gyrotron tube and the CEA. Connect cooling lines and dry air purge lines. TRW will provide coordination and technical assistance.

28) Fabricate and Install two (2) containment enclosures. Nominal dimensions of the enclosures are 10 feet wide, 22 feet long and 10 feet high. The enclosures consist of lexan panels in an aluminum angle frame. Fabricate and Install a HEPA filtered exhaust system with an exhaust fan for the enclosures.

29) Fabricate and Install a magnet work platform. The platform will be fabricated from non-magnetic materials.

30) Fabricate and Install a gyrotron work platform.

31) Install six (6) Alpha Constant Air Monitors. Three units will be installed on the Fab Lab service floor to monitor the air space. Fabricate and install ductwork from the three remaining units to sample points in the air conditioning return ducts.

32) Purchase and install a safety shower/eye wash combination unit.

33) Miscellaneous Items

- Check-out and run-in will be required for each subsystem after it is installed. TRW and Isotope Separations Division (ISD) will provide coordination and technical assistance. Check-out and run-in procedures will be as described in Construction Memorandum No. 70.

- A section of the floor in the high-bay area will be finished with an epoxy type sealant.

- Painting of walls, doors, structures, etc., will be required.

- Identification blocks will be affixed to all piping, conduits, switchgear, motor control centers, lighting panels, pumps and valves.

- Warning placards and warning lights will be required. The warning lights will indicate when the magnet is operating.

- Guard rails will be installed around the magnet and gyrotron area.

- The 100 gauss lines will be identified on the floor using safety marking tape.

- Testing will be required by PTL, T & I, etc. Testing will include pressure tests, concrete tests, and vacuum system tests.

- Construction scaffolding will be required around the magnet and gyrotron. ISD will use this scaffolding until the requirements for permanent platforms can be determined.

- Modifications to the Fire protection system will be required.

- Modifications to the lighting in the high-bay area will be required.

- Install a wall and door at the base of stairwell 17.

SCOPE OF WORK
ELECTRICAL
ES0883120
RELOCATE 13.8 KV TRANSMISSION LINE

This scope describes the work necessary to relocate a portion of the existing overhead 13.8 KV transmission line underground. The section of the 13.8 KV transmission line which is to be relocated is located east of section "D", 773-A. The line must be placed underground to enable the construction of the PSP power supply room.

1. Remove 25 feet of existing fence around substation 752-7A.

2. Extend fence around substation 752-7A eight feet north. Forty feet of new fence is to be installed.

3. Provide and install two (2) new 50 foot power poles with five (5) 4"X5"X10'0" crossarms.

4. Guy new power poles.

5. Provide and install three (3) suspension insulator pins.

6. Provide and install six (6) pin insulators.

7. Provide and install three (3) PSC cable terminals with aerial lugs and mounting bracket.

8. Provide and install outdoor fused interrupter switch with fuses.

9. Install ground grid for disconnect switch.

10. Provide and install 10' long copper ground rod.

11. Remove existing 13.8 KV overhead transmission line.

12. Hand dig 1'0" wide by 3'6" deep trench. Backfill and repave (150LF)

13. Provide and install 3-500 MCM 15KV cables in 4" conduit. (225LF)

14. Provide and install #4/0 bare copper ground cable. (150LF)

15. Remove two (2) existing power poles.

16. Provide and install one (1) 50 foot class 2 power pole with two (2) 4"X5"X10'0" crossarms.

17. Guy new power pole.

18. Provide and install three (3) suspension insulator pins.

19. Provide and install six (6) pin insulators.

20. Provide and install three (3) fused cutouts with fuses.

21. Provide and install three (3) PSC cable terminals with aerial lugs and mounting bracket.

22. Provide and install one (1) 10 foot long copper ground rod.

23. Hand dig 1'0" wide by 3'6" deep trench. Backfill and repave. (50LF)

24. Provide and install 3-#2/0 15KV cables in 4" conduit. (75LF)

25. Provide and install #4/0 bare copper ground cable. (50LF)

SCOPE OF WORK
ELECTRICAL
ES0883120
2500 KVA Substation for PSP

This scope describes the work necessary to purchase and install one (1) 2500 KVA substation for the PSP program. The substation will be located east of 773-A, Section "D".

1. Provide and install one (1) 28'0" X 14'0" X 6" reinforced concrete pad.

2. Purchase and install incoming line section, transformer and secondary switchgear.

3. Install breakers in secondary switchgear. Set breakers per coordination curve.

4. Connect incoming #2/0 15 KV cables to incoming line section of substation.

5. Provide and install 3-750MCM cables in 4" conduit from substation secondary switchgear to 90 KV power supply input section. (50LF) (Four conduit runs are required.)

6. Provide and install 3-750MCM cables in 4" conduit from substation secondary switchgear to 4 KV power supply input section. (50LF) (Four conduit runs are required.)

7. Hand dig 3'0" X 3'0" trench from substation secondary switchgear to Motor Control Centers. Backfill. (125LF)

8. Provide and install 6-350MCM cables in 4" conduit from substation secondary switchgear to Motor Control Center 32 located in PSP control room. (150LF)

9. Provide and install 6-350MCM cables in 4" conduit from substation secondary switchgear to Motor Control Center 33 located in PSP control room. (150LF)

Scope of Work
Electrical
ES 0883120
Install Motor Control Centers

1) Hand dig 3'0" x 3'0" trench for electrical conduits. Backfill (175LF)

2) Provide and install 6-350MCM cables in 4" conduit from substation to motor control centers. One conduit run is required for each motor control center. (200LF)

3) Purchase and install motor control centers.

4) Provide and install overload heaters for all motor starters.

5) Provide and install control wiring for each motor starter.

Scope of Work
Electrical
ES 0883120
Ground Well and Ground Bus Installation

1) Dig 15 foot deep by 3'0" diameter hole.

2) Install 15 foot long copper bus bar - 6" W x 1/4" thick.

3) Fill hole with non-conducting material such as salt.

4) Purchase and install 400 feet of 6" wide x 1/4" thick copper bus bar. The bus bar grounds the Power Supplies, Control Room, Gyrotron, and Magnet.

APPENDIX E

SRL PROJECT DRAWING AND M&E LISTS

Sorted By ENG

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
1		PSP-CTM-VACUUM PUMPS-ELEC	10/12/84	10/26/84	11/28/84			ALC/CAE	2100	ALC
2	SK5-5164LS	PSP-GROUND WELL INSTALLATION	7/30/84	10/B/84	10/16/84				9050	ALC
3	ST5-23208	DATA ACQ. CTR. LIGHTG. & RECEPT.			6/25/84	7/11/84	3	TOB	6000	CAE
4	ST5-23209	LIGHTING PANEL 49L POWER PLAN & DET			6/25/84			HGN	6000	CAE
5	ST5-23214	SUBSTATION 752-66A PLANS & S/L DIGM			6/21/84	8/24/84	1	TOB	8040	CAE
6	ST5-23215	SS 752-66A POWER & BLDG GROUND GRID & DETAILS			6/25/84	8/25/84	4	OJJ	9050	CAE
7	ST5-23216	MCC-32 & 33 DETAILS & S/L			6/4/84	6/5/84	2	TOB	6020	CAE
8	ST5-23217	POWER SUPPLY BLDG & POWER DETAILS			7/11/84	10/08/84	3	MDF	9080	CAE
9	ST5-24133	POWER SUPPLY BLDG DIAG PLAN & details			11/16/84			LDP		CAE
10	ST5-24134	COOLING WATER PUMPS INSTR DIAGRAMS			10/31/84	11/11/84		TOB		CAE
11	ST5-24135	INTERCOM SYSTEM						TOB		CAE
12	ST5-24136	P S BLDG A/C ELECTRICAL						TOB		CAE
13	ST5-28218	POWER SUPPLY BLDG FIRE DETECTION	10/12/84	10/19/84	10/24/84			TOB	9080 0	CAE
14	ST5-23231	JUNCTION BOX "B" PLAN & DETAILS			8/4/84			TOB	2020	CAE
15	ST5-23232	JUNCTION BOX "C" PLAN & DETAILS			11/5/84			HGN	4040	CAE
16	ST5-23233	JUNCTION BOX "D" PLAN & DETAILS			11/5/84			HGN	5040	CAE
17	ST5-23234	JUNCTION BOX "D" INTERCONN. DIAG.			8/8/84			HGN	5040	CAE
18	ST5-23235	JUNCTION BOX "E" PLAN & DETAILS			11/B/84			WJH	7040	CAE
19	ST5-23236	JUNCTION BOX "E" INTERCONN. DIAG.			8/28/84			WJH	7040	CAE
20	ST5-23237	JUNCTION BOX "F" PLAN & DETAILS			7/18/84			HGN	6020	CAE
21	ST5-23238	JUNCTION BOX "G" PLAN & DETAILS			8/4/84			TOB	2060	CAE
22	ST5-23899	13.8KV LINE RELOCATE PLAN			5/8/84		2	TOB	120	CAE
23	ST[illegible]3900	13.8KV LINE RELOCATION POLE DETAILS			5/8/84			TOB	1[illegible]	CAE

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
24	ST5-23213	SUBSTATION 752-66A PLOT PLAN		12/B/84				TOB	8040	CAE
25	ST5-24124	SUBSTATION 752-66A COORDINATION CURVES			10/09/84			TOB	8040	CAE
26		IGC MAGNET GROUNDING DETAILS			12/B/84				9050 0	CAE
27		GYROTRON COLLECTOR & GUN MAGNETS RECEPT. PL.			12/B/84				7070	CAE
28		MODULE SITE-RECEPTACLE PLAN			12/B/84				0	CAE
29	ST5-24139	COOLING WATER PUMPS-CONTROL PANEL DETAILS			11/8/84				3060	CAE
30	ST5-24137	COOLING TOWER ELECT PLOT PLAN			11/16/84				3050	CAE
31	ST5-24125	90KV POWER SUPPLY ELEC.PLAN & DETAILS			10/23/84			TOB	9040	CAE
32		INTERCOM SYSTEM PLAN & DETAILS		01/A/85					6000	CAE
33		INTERCOM SYSTEM INTERCONNECTION DIAG.		11/A/84					6000	CAE
34		TRANSFORMER GROUNDING PLAN & DETAILS		12/B/84					9050	CAE
35		90KV POWER SUPPLY GROUNDING PLAN & DET.		12/B/84					9050	CAE
36		4KV POWER SUPPLY GROUNDING PLAN & DET.		12/B/84	4				9050	CAE
37	ST5-24131	COOLING WATER PUMP,SCHEMATIC & S/L DIAGRAM	11/A/84		11/05/84				3030	CAE
38		GYROTRON GROUNDING PLAN & DETAILS		12/B/84					9050	CAE
39	ST5-24132	MOTOR CONTROL CENTERS CONDUIT PLAN			10/24/84			TOB	6020	CAE
40		DACC CONTROL CABINETS GROUNDING PLAN		12/B/84					9050	CAE
41		BLOWER MOTORS-POWER PLAN & DETAILS		12/A/84					•4070 •5070	CAE

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
42		POWER SUPPLY BLDG. A/C POWER PLAN & DETAILS		12/B/84					11000	CAE
43		PSP ALARMS-CONNECTIONS TO C-041		1/B/85					10030	CAE
44		HALON SYSTEM PLAN & DETAILS			11/B/84				6030 0	CAE
45		HALON SYSTEM-INTERCONNECTION DIAGRAM			11/B/84				6030 0	CAE
46	ST5-24130	LN2-LEVEL SWITCH-PLAN 7 DETAILS			10/17/84	10/27/84	5	JEM	1030	CAE
47		HP MONITORS-ELECTRICAL PLAN & DETAILS			2/A/85				10040	CAE
48	ST5-23211	POWER SUPPLY BLDG ELEC. RECP. & LTG			5/8/84	10/22/84	26		9000	CAE
49	ST5-24127	4KV POWER SUPPLY ELEC.PLAN & DETAILS	10/B/84		10/24/84			TOB	8060	CAE
50	ST5-24128	4KV POWER SUPPLY-CONDUIT PLAN	11/A/84		10/24/84			JEM	8060	CAE
51	ST5-24126	90KV POWER SUPPLY-CONDUIT PLAN	10/B/84		10/17/84			JEM	9040	CAE
52	ST5-23239	POWER SUPPLY BLDG CONDUIT RUNS DETAIL			11/08/84			TOB	9080	CAE
53	ST5-24218	FIRE DETECTION 773-50A PLAN & INTERCONNECTION DIAGRAM			10/25/84			TOB		CAE
54	ST5-24138	COOLING TOWER VIBRATING			11/9/84			JEM		CAE
55	ST5-24140	VAC SYS SOLENOID VENT VALVE VAC PUMP						LDP		CAE
56	ST5-24141	DEION WATER COOLING PUMPS								CAE
57	ST5-24142	COOLING TOWER PWR DISTR RACK			11/16/84			TOB		CAE
58	ST5-24143	COOLING TOWER PWR TPT SYST						JEM		CAE
59	ST5-24144	D.I. WATER TK SPARE HTRS			11/13/84			JEM		CAE
60	ST5-24149	VAC SYST RELAY BOX						TOB		CAE
61	S 24150	VAC PUMPS INSTR DIAGM						TOB		CAE
62	ST5-24151	VAC PUMPS PWR PLAN AND DETAILS						JEM		CAE

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
63	ST5-24152	DEION WATER TK LEVEL SWITCHES ELECT PLAN AND DETAILS						JEM		CAE
64	ST5-23201	DATA AQUISITION CENTER ARCH.			3/23/84	5/25/84	1	WJH	6000	EAS
65	ST5-23202	DATA AQUISITION CENTER WALL SECTION			5/25/84			WJH	6000	EAS
66	ST5-23203	DATA ACQUIST. FLOOR LAYOUT & SEC.			5/25/84	8/30/84	5	OJJ	6000	EAS
67	ST5-23210	CIVIL PLOT PLAN			5/4/84	7/18/84	7		9000	EAS
68	ST5-23212	POWER BLDG. CIVIL PLOT PLAN & ARCH.			5/4/84	8/14/84	22		9000	EAS
69	ST5-23219	POWER SUPPLY BLDG EQT ARRANGEMENT			9/27/84	10/19/84		DJT	°8000 °9010	EAS
70	ST5-23204	DATA ACQUISITION CEILING PLAN & SECTION	10/15/84		10/15/84			WSH	100	EAS
71	SV4-00130	POWER SUPPLY BLDG STRUCTURAL	10/5/84		10/05/84				9000	EAS
72	ST5-23230	NITROGEN GAS SERVICE	12/03/84					WJH	1100	EAS
73	ST5-	VAC INSULATED PIPING COLD TRAP FD LINE	01/A/85							EAS
74	ST5-24115	MAGNET FOUNDATION PLAN & DETAILS			9/12/84			OJJ	10	EAS
75	ST5-24111	VACUMM INSULATED PIPING SUPPORT PLN		10/4/84	10/04/84			OJJ	1030	EAS
76	ST5-24112	VAC INSULATED PIPING SUPORT&DETAILS SHEET 1		10/4/84	10/04/84			OJJ	1030	EAS
77	ST5-24113	VAC INSULATED PIPING DETAILS SHT 2		10/4/84	10/04/84			OJJ	1030	EAS
78	ST5-24114	VAC INSULATED PIPING DETAIL SHT 3		11/08/84	11/29/84				1030	EAS
79	SV4-00124	VACUUM INSULATED PIPING ELEVATION		10/4/84	10/04/84				1030	EAS
80	SV4-00125	VACUUM INSULATED PIPING PLAN		10/4/84	10/04/84				1030	EAS
81		PSP-BARRICADES, WARNING PLACARDS & LIGHTS	02/B/85						10030	EAS
82		PSP-WALL INSTALLATION, STAIRWELL 17	02/B/85						10030	EAS
83		PSP-8' PARTITION PLAN	02/B/85						10020	EAS
84		PSP 8' PARTITION DETAILS	02/B/85						10020	EAS

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
85	ST5-24133	P.S.BLDG DRAIN-PLAN & DETAILS		11/16/84					10020	EAS
86	ST5-5590	PRESS ELEC ARRANGMENT			11/5/85	4/17/70	6	REF DWG FOR PRESS REMOVAL	80	EAS
87	ST5-5591	EXTRUSION PRESS DRAIN			11/5/84			REF DWG FOR PRESS REMOVAL	80	EAS
88	ST5-5592	EXTRUSTION PRESS SERVICE PIPING			11/5/84	12/2/60	3	REF DWG FOR PRESS REMOVAL	80	EAS
89	ST5-5593	EXTRUSION PRESS FOUNDATION PLAN			11/5/84	2/22/60	1	REF DWG FOR PRESS REMOVAL	80	EAS
90	ST5-5594	EXTRUSION PRESS UNDERFLOOR PIPING ARRMG			11/5/84			REF DWG FOR PRESS REMOVAL	80	EAS
91	ST5-5595	EXTRUSION PRESS S/L AND WIRING			11/5/84	5/1/70	42	REF DWG FOR PRESS REMOVAL	80	EAS
92	ST5-5596	EXTRUSION PRESS CABLE DIAGRAM			11/5/84	12/2/60	18	REF DWG FOR PRESS REMOVAL	80	EAS
93	ST5-9525	LAB 480V S/L DIAGRAM MCC11 THRU MCC13			11/5/84	10/3/84	74	REF DWG FOR PRESS REMOVAL	80	EAS
94	ST4-9625	REVISIONS FOR DRAWING NO ST5-9525						REF DWG FOR PRESS REMOVAL	80	EAS
95	ST5-20427	PREHEAT FURANCE ELEC. PLAN AND DETAILS			11/5/84	4/5/79	6	REF DWG FOR PRESS REMOVAL	80	EAS
96	ST5-24116	D.I.WATER TANK,ASSY AND DETAILS			10/8/84			WJH SENT TO TANK VENDOR	3030	ETB
97	ST5-24117	D.I.WATER TANK,TOP DETAILS			10/8/84			WJH SENT TO TANK VENDOR	3030	ETB
98	ST5-24118	D.I.WATER TANK,TANK STAND			10/8/84			WJH SENT TO TANK VENDOR	3030	ETB
99	ST5-24123	COOLING WATER PIPING & EQUIPMENT PLAN SHT 2	12/84						3030	ETB
100	ST5-24147	COOLING WATER SYSTEM FLOW/P&I SHEET 1	12/84						3030	ETB
101	ST5-24148	COOLING WATER SYSTEM FLOW/P&I SHT 2	12/84						3030	ETB
102		D.I. WATER PIPING ELEV AND DETAILS	01/A/85						3030	ETB
103		D.I. WATER PIPING SUPORTS	01/A/85						3030	ETB
104		D.I. WATER PIPING SUPPORTS AND DETAILS	01/A/85						3030	ETB
105		D.I.AND COOLING PIP SUPORT DETAILS & MISC.	01/A/85						0	ETB

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
106	ST5-24122	COOLING WATER PIPING & EQUIPMENT PLAN SHT 1	12/84						3030	ETP
107	ST5-24101	VACUUM SYSTEM PLAN	12/B/84					MDP	2050	JCG
108	ST5-24102	VACUUM SYSTEM ELEVATION SHEET #1	12/B/84						2050	JCG
109	11/A/8403	VACUUM SYSTEM ELEVATION SHEET #2	12/B/84						2030	JCG
110	ST5-24104	VAC SYSTEM OIL TRAP ASSEMBLY & DETAILS	12/B/84						2050	JCG
111	ST5-24105	VAC SYSTEM FLANGE DETAILS	12/B/84						2000	JCG
112	ST5-24106	VAC SYSTEM PIPE SUPPORTS	12/B/84						2050	JCG
113	ST5-24107	VAC SYSTEM FILTER HOUSING	12/B/84						2090	JCG
114		PSP PIPE/CONDUIT SUPPORTS PLAN	12/A/84						*3020 *0030	JCG
115		PSP PIPE/CONDUIT SUPPORTS ELEVATION	12/A/84						*3020 *0030	JCG
116		PSP PIPE/CONDUIT SUPPORTS DETAILS	12/A/84						*3020 *0030	JCG
117	ST5-24129	CONDUIT ROUTING ISOMETRIC	12/B/84					WJH	*3020 *0030	JCG
118		PSP-GYROTRON WORK PLATFORM	11/1/84						7010	JES
119		GYROTRON WOPK PLATFORM DETAILS	11/1/84						7010	JES
120	ST5-24119	LAYOUT-EQUIP. CASE TO GROUND BUS	9/1/84	11/1/84	11/05/84				9050	JPF
121	ST5-24120	GROUND BUSBAR FABR. & INSTALLATION	9/1/84	11/1/84	11/01/84				9050	JPF
122	ST5-24121	EQUIP CASE TO GROUND BUS-DETAILS	9/1/84	11/1/84	11/1/84				9050	JPF
123		PSP-FC-75 CART	12/B/84						7060	JPF
124	ST5-23853	COOLING TOWER SUPPORT DETAILS	5/21/844		5/21/84			LDP	60	KJB
125		PSP-MAGNET WORK PLATFORM	2A85						10050	KJB
126		PSP-MAGNET WORK PLATFORM DETAILS	2A85						10050	KJB
127		PSP-AIR MONITORS	2A85						10040	KJB

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
128		PSP-AIR MONITOR INSTALLATION DETAILS	2A85						10040	KJB
129		PSP-SAFETY SHOWER/EYEWASH UNIT	2A85						10030	KJB
130	ST5-23222	CTM-ENCLOSURE ARRGT	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
131	ST5-23223	CTM-ENCLOSURE ARRGT & DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
132	ST5-23224	CTM-ENCLOSUSRE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
133	ST5-23225	CTM-ENCLOSURE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
134	ST5-23226	CTM-ENCLOSURE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
135	ST5-23227	CTM-ENCLOSURE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
136	ST5-23228	CTM-ENCLOSURE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
137	ST5-23229	CTM-ENCLOSURE DETAILS	10/22/84	01/15/84			OJJ		©4060 ©5060	PAM
138	SV-00031	HELIUM VENT LINE ARRGT.	10/1/84	10/29/84	11/20/84				1040	PAM
139	SV-00032	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
140	SV-00033	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
141	SV-00034	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
142	SV-00035	HELIUM VENT LINE DETIALS	10/1/84	10/29/84	11/20/84				1040	PAM
143	SV-00036	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
144	SV-00037	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
145	SV 00038	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
146	SV-00039	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
147	SV 040	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1[illegible]	PAM

PSP DRAWING SCHEDULE

REC#	DRAWING #	DRAWING TITLE	SCHED IS PRELIM	SCHED IS FINAL	ISSUE DATE	REVISED DATE	REV #	REMARKS	TASK#	ENG
148	SV-00123	HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
149	ST5-24145	MAGNET HELIUM VENT LINE ARRGT.	10/1/84	10/29/84	11/20/84				1040	PAM
150	ST5-24146	MAGNET HELIUM VENT LINE DETAILS	10/1/84	10/29/84	11/20/84				1040	PAM
151	ST5	INTERFACE-FLEX D I WATER CEA	12/B/84						4020	PAM
152	ST5	INTERFACE-FLEX D I WATER SEA	12/B/84						5020	PAM
153	ST5	INTERFACE-FLEX D I WATER DETAILS	12/B/84						©4020 65020	PAM
154	ST5	COMPRESSED AIR DRYER ARRGT	12/B/84						2080	PAM
155	ST5	EXHAUST SYST CTM ENCLOSURE CEA	12/B/84						4070	PAM
156	ST5	EXHAUST SYST CTM ENCLOSURE SEA	12/B/84						5070	PAM
157	ST5	EXHAUST SYST CTM ENCLOSURE DETAILS	12/B/84C						©4070 ©5070	PAM
158	ST5	EXHAUST SYST CTM ENCLOSURE DETAILS	12/B/84						©4070 ©6070	PAM
159	ST5	ARGON SUPPLY-ARGON INJECTION SYST	12/B/84						5100	PAM
160	SV5-00063	PSP-CTM SERVICE FLOOR PLAN	9/6/84				3	J.E.SIRRINE REF DRAWING ONLY	0	PAM
161		PSP COMPRESSED AIR PIPING	12/B/84						2080	PAM
162		PSP COMPRESSED AIR PIPING DETAILS	12/B/84						2080	PAM

E-9

PAGE NO. 00001
01/04/85

† CHARGED TO 8581-IP
EWO'S CONVERTED TO S-4182
X NOT ORDERED

PSP MATERIAL & EQUIP LIST

EWO	REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
†	1		1	ALPHA #5370/16AWG CABLE		0	LSD	NEWARK	T27586	675446	10/26/84				CAE
05	2		1	PSP SUBSTATION 752-66A		0	LSD	GENERAL ELEC.	68959		8/30/84	REC'D	2500KVA SUBSTATION	8040	CAE
06	3		2	MOTOR CONTROL CENTERS MCC-32 MCC-33		0	LSD	SIEMEN-AL LIS	68969		8/30/84	REC'D	MOTOR CONTROL CENTERS	6020	CAE
†	4		1	CIRCUIT BREAKER PANELBOARD		0	LSD	SQUARE 'D'	T08749	669205			DACC 208Y/120V PWR LIGHTING PANL49L	100	CAE
†	5		2	30 AMP 1 POLE BREAKER		0	LSD	SQUARE 'D'	T08749	669205			CIRCUIT BREAKER FOR GYROTRON GUN MG	0	CAE
†	6		25	20 AMP 1 POLE BREAKER		0	LSD	SQUARE 'D'	T08749	669205			PSP 120V, 20AMP OUTLETS	0	CAE
†	7		3	30 AMP 3 POLE BREAKER		0	LSD	SQUARE 'D'	T08749	669205			IGC MAGNET POWER SUPPLIES	0	CAE
†	8		3	30 AMP, 2 POLE BREAKER		0	LSD	SQUARE 'D'	T08749	669205			PSP 208, 10, 30AMP OUTLETS	0	CAE
†	9		75	ISOLATED GROUND BNC.		0	LSD	H.C. NORMAN CO	T05934	665157	7/6/84		JUCTION BX COAXIAL BX BNC CONNECTOR	0	CAE
†	10		100	BNC STRAIGHT PLUGS		0	LSD	NEWARK ELECTR.	T05936	665197	7/6/84		JUNC. BX COAXIAL CABLE	0	CAE
†	11		100	BNC ANGLE PLUGS		0	LSD	NEWARK ELECT.	T05936	665197	7/6/84		JUNC BX COAXIAL CABLE	0	CAE
†	12		1	45KVA TRANSFORMER		0	LSD	SQUARE 'D'	R99958		7/13/84	REC'D	PWR SUPPLY BLDG LIGHTING PANEL PWR	9010	CAE
†	13		1	75KVA TRANSFORMER		0	LSD	SQUARE 'D'	R99958		7/13/84	REC'D	LIGHTING PANEL "49L" POWER		CAE
†	14		1	100 AMP DISCONNECT		0	LSD	SQUARE 'D'	R99958	665171	7/13/84		DISCONNECT SW FOR 45KVA TRANSFORMER	0	CAE

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
+ 15		1	200 AMP DISCONNECT		0	LSD	SQUARE 'D'	R99958	665171	7/13/84		DISCONNECT SW FOR 75KVA TRANSFORMER	0	CAE
+ 16		2	30" X 24" X 6 5/8" ENCLOSURE		0	LSD	CTRL SPECIALIS	T08748		7/6/84		JUNCTION BOX "E" & "D"	5040 7040	CAE
+ 17		1	20" X 16" X 6 5/8" ENCLOSURE		0		CTRL SPECIALIS	T08748		7/6/84		JUNCTION "B"	2020	CAE
+ 18		1	10" X 10" X 6" ENCLOSURE		0	LSD	CNTL SPECIALIS	T08748		7/6/84		JUNCTION BOX "F"	6020	CAE
+ 19		2	14" X 12" X 6" ENCLOSURE		0	LSD	CNTL SPECIALIS	T08748		7/6/84		JUNCTION BOX "C" & "G"	4040 2060	CAE
+ 20		1	PANEL FOR ENCLOSURE 8 1/4" X 8 1/4"		0	LSD	CNTL SPECIALIS	T08748		7/6/84		JUNCTION BOX "F"	6020	CAE
+ 21		2	PANEL FOR ENCLOSURE 12 1/4X12 1/4"		0	LSD	CNTL SPECIALIS	T08748		7/6/84		JUNCTION BOX "C" & "G"	4040 2060	CAE
+ 22		3	TERMINAL STRIPS-SIZE 12		0	LSD	NEWARK ELECTR.	T05927		7/6/84		JUNCTION BOX "B"	2020	CAE
+ 23		5	TERMINAL STRIPS-SIZE 11		0	LSD	NEWARK ELECT.	T05927		7/6/84		JUNCTION BOX "B" & "F"	2020 6020	CAE
+ 24		10	TERMINAL STRIPS-SIZE 19		0	LSD	NEWARK ELECT	T05927		7/6/84		JUNCTION BOX "D"	5040	CAE
+ 25		10	TERMINAL STRIPS-SIZE 15		0	LSD	NEWARK ELECT.	T05927		7/6/84		JUNCTION BOX "E"	7040	CAE
+ 26		2	TERMINAL STRIPS-SIZE 14		0	LSD	NEWARK ELECT	T05927		7/6/84		JUNCTION BOX "G"	2080	CAE
+ 27		3	TERMINAL STRIPS-SIZE 17		0	LSD	NEWARK ELECT.	T05927		7/6/84		JUNCTION BOX "C"	4040	CAE
+ 28		6	THERMAL DETECTOR		0	LSD	PYROTRONICS	R99766	668687	7/27/84	REC'D	PWR SUPPLY BLDG FIRE DETECTION	9080	CAE
+ 29		1	END-OF-LINE DEVICE		0	LSD	PYROTRONICS	R99766	668687	7/27/84		PWR SUPPLY BLDG FIRE DETECTION	9080	CAE

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
+ 30		1	ALARM HORN		0	LSD	PYROTRONICS	R99766	668687	7/27/84		PWR SUPPLY BLDG FIRE DETECTION	9080	CAE
+ 31		30	ALPHA #5481 CABLE		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 32		2	ALPHA #5482/22AWG CABLE		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 33		2	ALPHA #5483/22AWG CABLE		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 34		4	ALPHA #5384/18AWG CABLE		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 35		3	5 TERMINAL BARRIER STRIP		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 36		2	17 TERMINAL BARRIER STRIP		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 37		6	TERMINAL BARRIER STRIP		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 38		5	20 TERMINAL BARRIER STRIP		0	LSD	NEWARK	T15878	669423	7/27/84			0	CAE
+ 39		7	COAX. CABLE #9058C ALPHA R658C/U		0	LSD	NEWARK	T15882	669454	7/27/84	REC'D		0	CAE
+ 40		1	ALPHA #5366/16AWG CABLE		0	LSD	NEWARK	T15882	669454	7/27/84	REC'D		0	CAE
+ 41		1	ALPHA #5464/20AWG CABLE		0	LSD	NEWARK	T15882	669454	7/10/84	REC'D		0	CAE
+ 42		4	ALPHA #5383/18AWG CABLE		0	LSD	NEWARK	T15882	669454	7/10/84	REC'D		0	CAE
+ 43		1	ALPHA #5459/20AWG CABLE		0	LSD	NEWARK	T15882	669454	7/27/84	REC'D		0	CAE

PSP MATERIAL & EQUIP LIST

EWO	REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
+	44		1	ALPHA #5193/22AWG CABLE		0	LSD	NEWARK	T15882	669454	7/27/84	REC'D		0	CAE
+	45		1	MOTOR CONTROL CENTER SECTION 6		0	LSD	SIEMENS ALLIS	T15894		10/19/84		REC'D	6020	CAE
+	46	0	2	HM DOOR W/HARDWARE	ST5-23201	663995	SRL	MANER BLDG SUP	99953	553995	05/28/84	REC'D	DATA ACQUISITION CENTER	6000	EAS
+	47	0	1	WINDOW	ST5-23201	8	SRL	SERVICE GLASS	R99952	664054	6/18/84	REC'D	DATA ACQUISITION CENTER	6000	EAS
08	48		1	166' VACUUM JACKET PIPING 1 1/4"OD		0	LSD	CVI	T05112	664138	10/12/84	REC'D	INCL. CRYOGENIC VALVES LN2 TRANSF.	1030	EAS
03	49		1	12" RAISED FLOOR		0	LSD			Ax 664169		REC'D	DATA ACQUISITION CENTER [INSTALLED]	6000	EAS
02	50		1	30'X48' METAL BUILDING	ST5-23210	0	LSD		R99953	Ax 664139	10/10/84	REC'D	POWER SUPPLY BLDG.	9000	EAS
+	51		2	SPRING HANGERS		0	ISD			T05120	10/12/84	REC'D		1030	EAS
+	52		2	PIPE ROLL SUPPORT		0	ISD			T27553			N/R	1030	EAS
04	53		1	HALON FIRE SUPR. SYS.		0	LSD		T27583		11/16/84		TO BE INSTALLED BY VENDOR	6030	EAS
01	54	0	1	COOLING TOWER		0	LSD			Ax651626	6/29/84	REC'D	DI WATER SYST (OUTSIDE)	3000	ETB
AMO	55		1	D. I. STORAGE TANK		0	CON	MIDLAND STEEL		AXC85172			DI COOLING SYSTEM	3020	ETB
AMO	56		2	D. I. STORAGE TANK IMMERSION HEATER		0	CON	WATLOW		AXC85172			DI COOLING SYSTEM	3030	ETB
AMO	57		1	HIGH PRESSURE D.I. PUMP & MOTOR		0	CON	GOULDS PUMPS I		AXC85170			DI COOLING SYSTEM	3030	ETB

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP ACT RECV	REMARKS	TASK #	ENG
AMO 58		1	LOW PRESSURE D.I. PUMP & MOTOR		0	CON	GOULDS PUMPS I		AXC85170		DI COOLING SYSTEM	3030	ETB
X 59		1	HP PRESSURE SYS PARTICULATE FILTER		0	LSD					DI COOLING SYSTEM	3030	ETB
X 60		1	LP SYS PARTICULATE FILTER		0	LSD					DI COOLING SYSTEMS	3030	ETB
AMO 61		1	HIGH PRESSURE HEAT EXCHANGER		0	CON	MUELLER		AXC85169		DI COOLING SYSTEM	3030	ETB
AMO 62		1	LOW PRESSURE HEAT EXCHANGER		0	CON	MUELLER		AXC85169		DI COOLING SYSTEM	3030	ETB
X 63		9	DE-IONIZER		0	LSD	CONTIN WATER D				DI COOLING SYSTEM	3030	ETB
X 64		1	COOLING TOWER WTR TREATMT SYSTEM		0	CON	NALCO				DI COOLING SYSTEM	3010	ETB
AMO 65		1	COOLING TOWER PUMP "A" & MOTOR		0	CON	GOULDS PUMPS I		AXC85170		DI COOLING SYSTEM	°3010 °3010	ETB
AMO 66		1	COOLING TOWER PUMP "B" & MOTOR		0	CON	GOULDS PUMPS I		AXC85170		DI COOLING SYSTEM	3010	ETB
AMO 67		1	COOLING TOWER STRAINER		0	CON	ZURN INDUSTRIE				D I COOLING SYSTEM	3010	ETB
X 68		2	8" EX. JOINTS COOLING TWR PUMP/PIPE		0	LSD	METRAFLEX				METRAFLEX, T-2-T	3010	ETB
X 69		2	6" EX. JOINTS COOLING TWR PUMP/PIPE		0	LSD	METRAFLEX				METRAFLEX, T-2-T	3010	ETB
X 70		3	LEVEL SWITCHES FOR STORAGE TANK		0	LSD	GEMS				LS-2050	3060	ETB

PSP MATERIAL & EQUIP LIST

EWO	REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
X	71		1	BY-PASS VALVE W/PILOT, LP SYS 2 1/2		0	LSD	SORRELL					C. M. BAILEY	3060	ETB
X	72		1	BY-PASS VALVE W/PILOT, MP SYS 4"		0	LSD	SORRELL					C. M. BAILEY	3060	ETB
X	73		1	BY-PASS VALVE W/PILOT COOLING TOWER		0	LSD	SORRELL					C. M. BAILEY	3010	ETB
X	74		2	CONTROL VALVE FOR COOLING WATER		0	LSD							3060	ETB
+	75		2	OIL SEPARATORS	ST5-24101	0	ISD	PENWALT STOKES		657517	11/1/84	REC'D	MODEL P/N 291-1505	2000	JCG
+	76		2	WATER MISERS	ST5-24101	0	ISD	PENWALT STOKES		657517	11/1/84	REC'D	MODEL P/N 900-412-124	2000	JCG
E-15 +	77		6	DOP TEST FITTINGS	ST524102-3	0	LSD			657517	11/1/84	REC'D		2000	JCG
+	78		1	4" RAIN CAP	ST5-24103	0	LSD			657517	11/1/84	REC'D		2000	JCG
+	79		2	12"X12"X11 1/2" HEPA FILTER	ST5-24107	0	LSD	FLANDERS FILTE			11/1/84		MODEL # 7075-L/OR EQ.	2090	JCG
+	80		3	ROTAMETER W/LL ALARM		0	LSD	SCHUTE & KOERT			11/1/84		LO-FLO ALARM ROTAMETER	2000	JCG
+	81		3	MAGNEHELIC PRESSURE GAGE		0	LSD	DWYER INSTRUM.			11/1/84		DWYER SERIES 2000 MODEL #2004	2000	JCG
07	82	0	2	DIFFUSION PUMPS 20"		0	ISD	VARIAN		Ax 648183	9/14/84	REC'D	MAGNET SYSTEM	2120	MAR
X	83	0	6	ALPHA AIR MONITORS		0	ISD						FACILITY FAB LAB	10040	MAR
TAW	84		1	1.5 TESLA MAGNET		0	ISD	IGC			6/15/84	REC'D	MAGNET SYSTEM	1010	MAR
TAW	85		1	BORE TUBE STAND		0	ISD	TRW			6/10/84	REC'D	MAGNET SYSTEM	1000	MAR

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
TRW 86		1	PUMPOUT CHAMBER STAND		0	ISD	TRW			6/10/84		MAGNET SYSTEM	1000	MAR
X 87		1	LIQUID HELIUM DEWAR		0	ISD	AIR PRODUCTS					CRYOGENICS SHIP ON REQUEST	1020	MAR
TRW 88		1	PROCESS BORE TUBE		0	ISD	TRW					MAGNET SYSTEM SHIP ON REQUEST	1080	MAR
TRW 89		1	PUMP OUT CHAMBER		0	ISD	TRW					MAGNET SYSTEM SHIP ON REQUEST	2110	MAR
TRW 90		1	90 KV POWER SUPPLY		0	ISD	UVC			10/15/84	REC'D	IN PWR SUPPLY BLDG MAGNET PWR SUPLY	9010	MAR
TRW 91		1	4KV POWER SUPPLY		0	ISD	UVC			1/28/85		MAGNET POWER SUPPLY	8000	MAR
TRW 92		1	GYROTRON TUBE		0	ISD	VARIAN			11/05/84		GYROTRON MW SYST	7110	MAR
TRW 93		1	GYROTRON MAGNET		0	ISD	VARIAN				REC'D	GYROTRON-MW SYSTEM	7070	MAR
TRW 94		1	GYROTRON INNER STAND		0	ISD	TRW			10/31/84		GYROTRON-MW SYSTEM	7010	MAR
TRW 95		1	FC 75 CART		0	ISD	TRW			12/4/84		COOLING SYS-MW WAVE GUIDE	7060	MAR
TRW 96		1	VACUUM SYSTEM CONTROL&MONITO R PANEL		0	ISD	TRW			10/9/84		RETURNED TO TRW	6010	MAR
TRW 97		1	TRW VACUUM PIPING		0	ISD	TRW					SHIP ON REQUEST	2030	MAR
TRW 98		1	SOLENOID VALVE PANEL		0	ISD	TRW			10/1/84			2060	MAR
TRW 99		1	SEAL VACUUM CONTROL & MONITOR PANEL		0	ISD	TRW			10/09/84		RETURNED TO TRW	0	MAR
TRW 100		1	LN2 CONTROL PANEL		0	ISD	TRW					SHIP ON REORESТ	0	MAR

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP ACT RECV	REMARKS	TASK #	ENG
101		1	ECRH TRANSMISSION SYSTEM		0	ISD	TRW			11/14/84	INCLUDING WAVEGUIDE & STRONGBACK	*7030 *7020	MAR
102		1	RF WATER LOAD		0	ISD	VARIAN			9/28/84	FOR GYROTRON	7090	MAR
103		1	DC WATER LOAD		0	ISD	TRW			11/13/84	FOR POWER SUPPLIES	9060	MAR
104		1	CEA TRANSPORTER		0	ISD	TRW				SHIP ON REQUEST	4000	MAR
105		1	SEA TRANSPORTER		0	ISD	TRW				SHIP ON REQUEST	5000	MAR
106		1	VARIAN ARC DETECTOR		0	ISD	TRW			11/15/84		7110	MAR
107		1	GYROTRON MAGNET CONTROL & INT LOCK PN		0	ISD	TRW			12/6/84	PANEL	7040	MAR
108		1	COLLECTOR END ASSEMBLY(CEA)		0	ISD	TRW			12/6/84	SHIP ON REQUEST	4010	MAR
109		1	SOURCE END ASEMBLY(SEA)		0	ISD	TRW			12/6/84		5010	MAR
110		1	TERMINATION PLATE AND CEA INTERNALS		0	ISD	TRW			12/21/84	SHIP ON REQUEST	4010	MAR
111		1	NEUTRAL SOURCE		0	ISD	TRW			12/21/84		10060	MAR
112		1	MAIN MAGNET FIELD INTERLOCK PANEL		0	ISD	TRW			12/24/84	PANEL & MONITOR	0	MAR
113		1	PROBE POSITION CONTROLLER PANEL		0	ISD	TRW			11/30/84		0	MAR
114		1	SYSTEM INTERLOCK PANEL		0	ISD	TRW				SHIP ON REQUEST	0	MAR
115		1	PROBE BIAS CONTROL PANEL		0	ISD	TRW				SHIP ON REQUEST	0	MAR

PSP MATERIAL & EQUIP LIST

EWO	REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
TRW	116		1	DIAGNOSTICS		0	ISD	TRW			1/2/85			0	MAR
	117		1	ARC DETECTION PANEL		0	ISD	TRW			1/4/85			0	MAR
	118		1	AIR PURGE LO/HI		0	ISD	TRW			1/2/85			7030	MAR
	119		1	ARGON INJECTION CONTROL PANEL		0	ISD	TRW						0	MAR
	120		1	ARGON PIEZO VALVE & CONTROLLER		0	ISD	TRW			1/7/85	REC'D	ARGON INJECTION	0	MAR
TRW	121		1	CONTROL ALARM PANEL		0	ISD	TRW					SHIP ON REQUEST	0	MAR
07	122		2	NITROGEN COLD TRAP-24 INCH.		0	ISD			648180				2040	MAR
+	123		2	24"VACUUM GATE VALVES		0	ISD	TORP-VAC		648198	9/12/84			2040	MAR
+	124		1	FLUKE MULTI FUNCTION COUNTER		0	ISD	J.FLUKE		653577	REC'D		TRAILER, 6613 TAG NO.	0	MAR
+	125		1	SPECTRUM ANALYZER (MODEL-HP)		0	ISD	H.P.		653556	REC'D		TRAILER, 6635 TAG NO.	0	MAR
+	126		1	STRIP CHART RECORDER		0	ISD	H.P.		653557	REC'D		TRAILER, 6630-6634 TAG NOS.	0	MAR
+	127		1	OSCILLOSCOPE H.P. MODEL + OPTIONS		0	ISD	H.P.	D	653558	REC'D		TRAILER, 6628-6629 TAG NOS.	0	MAR
+	128		1	DIGITAL VOLTMETER		0	ISD	H.P.		653559	REC'D		TRAILER, 6618-6619 TAG NOS.	0	MAR
+	129		1	MICROWAVE POWER METER		0	ISD	H.P.		653560	REC'D		TRAILER, TAG NO.6614	0	MAR

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP ACT RECV	REMARKS	TASK #	ENG
+ 130		1	NARDA MICROWAVE RADIATION METER		0	ISD	NARDA		653567	REC'D	TRAILER, 6620 TAG NO	0	MAR
+ 131		1	BELL GAUSS METER		0	ISD	F.W.BELL		653568	REC'D	TRAILER, TAG NO. 6615	0	MAR
+ 132		2	VEECO LEAK DETECTORS		0	ISD	VFFCO		653570	REC'D	FAB LAB, 6600-6601 TAG NOS.	70	MAR
+ 133		3	ION GAUGE CONTROLLERS		0	ISD	GRANVILLE		653574	REC'D	TRAILER, 6621-6623 TAG NOS.	0	MAR
+ 134		1	BOXCAR INTEGRATOR		0	ISD	FGG-PARC		653583	REC'D	TRAILER, 6616 TAG NO	0	MAR
+ 135		2	X-Y RECORDER PULSE GENERATOR		0	ISD	H.P.		653596	REC'D	TRAILER, 6610-6612 TAG NO	0	MAR
+ 136		2	VACUUM PUMPS MODEL 1395-M-01		0	ISD	SARGENT-W ELCH		654063	REC'D	305-M,6608-660 9 TAG NOS.	2000	MAR
+ 137		2	VACUUM PUMPS + ACCES.		0	ISD	PENNWALT-STOKE		657517	REC'D	305-M, 6602-6603 TAG NOS.	2000	MAR
+ 138		2	WAVETEX FUNCTION GENERATOR RACK		0	ISD	WAVETEK		657797	REC'D	TRAILER, 6624-6625	0	MAR
+ 139		2	DIGITAL VOLTMETERS		0	ISD	H.P.		665169	REC'D	TRAILER ,6742-6743 TAG NOS.	0	MAR
+ 140		1	GAUSS METER + ACCESS.		0	ISD			675927		N/R	0	MAR
+ 141		1	TEKTRONIX OSCILLOSCOPE		0	ISD			653569		N/R	0	MAR
TRW 142		2	GYROTRON MANIFOLDS		0	ISD	TRW			11/14/84		7010	MAR

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
† 143		1	I-BEAM, WIDE FLANGE		0	ISD	AUGUST MILL		677155	REC'D		FOR BORE TUBE INSTALLATION	1080	MAR
TRW 144		1	MAGNET CONTROL CABINET		0	ISD							0	MAR
145		1	15 3/4 X 19 PANEL		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
146		11	5 1/4 X 19 PANEL		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
147		18	7 X 19 PANEL		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
148		12	3 1/2 X 19 PANEL		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
149		1	8 3/4 X 19 PANEL		0	ISD	TRW				REC'D	CONTROL ROOM PANEL	0	MAR
150		1	68 X 68 PANEL "A"		0	ISD	TRW				REC'D	CONTROL ROOM PANEL	0	MAR
151		1	68 X 12 PANEL COAX PATCH		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
152		1	1 1/2 X 19 PATCH PANEL		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
153		1	7 X 19 PATCH PANEL "B"		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
154		1	7 X 19 PATCH PANEL SIG. "A", SIG 5E		0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
155		2	VERTICAL CABINET R-701924-XS		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
156		1	VERTICAL CABINET R-701924-XL		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
TRW 157		1	VERTICAL CABINET R-701924-XR		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
TRW 158		4	DOOR D-7019-LH-FV		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
159		5	SLOPE VERT CAB RS-42-(17)-192 4-XS		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
160		1	SLOPE VERT CAB RS-42-(17)-192 4-XL		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
161		6	DOOR D-4219-LH-FV		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
162		7	MULTI-BAY HARDWARE HM-67		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
163		2	WEDGE W-45-7024		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
164		3	SHELF WRITING SURFACE WS2-519		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
E-21 165		6	PAIR SUPPORT ANGLES SA-24		0	ISD	OPTIMA SCIENTF				REC'D	CONTROL ROOM RACKS	6010	MAR
166		10	10.5 X 19 PANEL	61-014	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
167		12	14 X 19 PANEL	61-016	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
168		2	15 X 19 PANEL	61-017	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
169		1	1 3/4 X 19 PANEL	61-009	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
170		1	5 3/4 X 19 PANEL	61-011	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
TRW 171		3	3 1/2 X 19 PANEL	61-601	0	ISD	TRW				REC'D	CONTROL ROOM RACKS	0	MAR
+ 172		5	PIPE ROLL STAND 12" FIG. 271		0	ISD	ITT GRNNEL	T08044	665617		REC'D		1040	PAM

PSP MATERIAL & EQUIP LIST

REC#	EP #	QTY	DESCRIPTION	DRAWING #	VPF #	P RESP	VENDOR	REQ #	AX #	PROM SHP	ACT RECV	REMARKS	TASK #	ENG
+ 173		1	AIR LINE LUBRICATOR SCHRADER #804FR		0	ISD	TIDEWATER SUPP	T15266	665631				2080	PAM
+ 174		8	SWIVEL JOINTS, SS, 20F #0PW 3920F3		0	ISD	RICHMOND SUPPL	T08037	648115				°4030 °5030	PAM
+ 175		1	MAGNET HELIUM VENT LINE		0	ISD	CRYOGEN CONSUL	T08026	648110		REC'D		1040	PAM
+ 176		1	AIR DRYER, PRE FILTER AUTO DRAIN		0	ISD	ABERNATHY -THOM	T08047	665318	10/1/84	REC'D		2080	PAM
+ 177		2	CHECK VALVE NUPRO. SS-8C4-25		0	ISD	GA VALVED FRTL	T08050	665318		REC'D		2080	PAM
+ 178		4	FLEXIBLE HOSE, EVER FLEX		0	ISD							°4020 °5020	PAM
+ 179		2	HEPA FILTER HOUSING/TEST SECTIONS		0	ISD							°4070 °5070	PAM
+ 180		2	1000 CFM EXHAUST BLOWERS		0	ISD							°4070 °5070	PAM
+ 181		8	MAGNEHELLIC GAUGES 0 TO 1" WC		0	ISD							°4070 °5070	PAM
TRW 182		1	D C BLOCK		0	ISD	VARIAN					REC'D	7110	MAR
TRW 183		1	MOD FILTER		0	ISD	VARIAN				REC'D		7110	MAR

USE

APPENDIX F

TRW DOCUMENTATION ON CTM

CTM REQUIREMENTS DOCUMENTS

Title	Number (PSP-SR-)	Status
o Technical Specification for a 4kv-160A Power Supply	39	Comp.
o CW Gyrotron Power Supply and Mount Assembly Specification	69	Comp.
o Component Test Module System Design Requirements	98	Comp.
o CTM-1 Source Design Requirements	107	Comp.
o SRL Components Test Module Facility Requirements Document	116	Comp.
o CTM Fluorocarbon Coolant System Requirements	119	Draft
o CTM ECRH Transmission System Design Requirements	120	Comp.
o CTM Source/Source End Assembly Design Requirements	121	Comp.
o CTM Bore Tube Design Requirements	123	Comp.
o CTM Process Vacuum Subsystem Requirements	124	Comp.
o CTM Central Alarm Subsystem Requirements	125	Comp.
o CTM Probe Position Control Subsystem Requirements	126	Comp.
o CTM System Level Interlock Subsystem Requirements	127	Comp.
o CTM Bore Vacuum Control Subsystem Requirements	128	Comp.
o Control Center Subsystems Requirements	129	Comp.
o CTM Pneumatic Valve Control Subsystem	131	Comp.
o CTM LN2 Control Subsystem Requirements	132	Comp.
o CTM Arc Detector Subsystem Requirements	133	Comp.
o CTM Seal Pump Vacuum Control Subsystem Requirements	134	Comp.

o CTM Argon Gas Injection Subsystem Requirements 135 Comp.

o CTM 1.5 Tesla Magnet/Bore Tube/Vacuum Pumpout Chamber Structural Support Assembly Design Requirements 137 Comp.

o CTM Vacuum Pumpout Chamber Design Requirements 138 Comp.

o CTM Diagnostic Design Requirements 141 Comp.

o Instrumentation and Control Subsystem 142 Draft.

o CTM Source End Assembly and Collector End Assembly Trasporter Design Requirements 143 Comp.

o CTM Collector End Assembly Design Requirements 145 Como.

o CTM Interface Control Document 150 Comp.

o CTM Gyrotron Stand Design Requirements 154 Comp.

o CTM Gyrotron Magnet Controller & Interlock Requirement 155 Comp.

o CTM Magnetic Field Sensor & Interlock Requirement 156 Comp.

o CTM Langmuir Bias Box Requirement 157 Comp.

o CTM Helium Vent Stack Design Requirements 158 Comp.

o CTM Gyrotron Stand System Level Requirements 163 Comp.

o CTM Bore Tube Water Monitor Subsystem Requirements 172 Comp.

o CTM Gyrotron Power Supply Water Load Subsystem Requirements 173 Draft.

o Component Test Module Gyrotron Magnet Power Supply Stand 175 Comp.

o CTM Source Power Supply Water Load Subsystem Requirements 177 Draft.

o CTM Operating Point (TRWA-87056-0556, classified) Comp.

CTM MECHANICAL AND ELECTRICAL PROCEDURES 1-30-85
REV. 2/25/85

Title	Number (PSP-24P-)	Status
o CTM SEA/CEA transporter alignment and movement procedure	297	Deferred
o CTM sub-system installation alignment	298	Comp.
o CTM Bore tube cooling water system installation	300	Comp.
o CTM Bore vacuum system installation procedure	301	Comp.
o CTM Bore vaccum leak check	302	Comp.
o Liquid nitrogen cold trap control subsystem operation and maintenance manual	322	Draft
o Bench test procedure for Langmuir probe	312	Comp.
o CTM seal vacuum system controller test plan	314	Document missing
o Bore vacuum controller bench test procedure	316	Comp.
o Liquid nitrogen cold trap control subsystem bench test procedure	320	Comp.
o Liquid nitrogen cold trap control subsystem operation and maintenance manual	322	Draft
o CTM seal vacuum controller installation and checkout procedure	325	Comp.
o CTM argon gas injection controller installation and checkout procedure	328	Comp.
o Installation and operating procedure for the Argon gas injection control	329	Draft
o CTM probe position control system bench test procedure	330	Comp.
o Langmuir probe bias unit installation and checkout procedure	337	Comp.

Title	Number (PSP-24P-)	Status
o CTM Langmuir probe bias unit operating and maintenance procedure	338	Comp.
o Gyrotron magnet control and interlock panel bench test procedure	339	Comp.
o Gyrotron magnet control and interlock panel installation and checkout procedure	340	Draft
o CTM installation and checkout for the magnetic field sensor and interlock	344	Comp.
o Pilot solenoid valve panel test procedure	345	Comp.
o Installation and checkout procedure for the pilot solenoid valve panel	346	Comp.
o FC-7S Bench Test Procedures	351	Comp.
o Gyrotron tank, tube, stand, outer stand and LOAD integration procedure	356	Comp.
o CEA mechanical checkout procedures for CTM	358	Comp.
o CEA mechanical integration procedures	359	Comp.
o Central alarm subsystem bench test procedure	362	Comp.
o CEA mechanical assembly procedures	366	Comp.
o SEA CTM mechanical integration procedure	368	Deferred
o CTM CEA shipping procedures	370	Contested in signoff
o CTM directional coupler & 200 KW water load installation and operating procedure	371	Draft
o CTM system level interlock subsystem bench test procedure	372	Draft
o SEA mechanical assembly procedures	377	Comp.
o SEA mechanical checkout procedures	378	Comp.
o CTM SEA shipping procedures	379	Deferred

Title	Number (FSP-24P-)	Status
o CTM CEA operating procedure	TBD	Deferred
o CTM SEA mechanical integration procedure	TBD	Deferred
o CTM SEA operating procedure	TBD	Deferred
o CTM gyrotron cooling panel shipping procedure	TBD	Deferred
o CTM gyrotron test plan	TBD	Deferred
o CTM gyrotron operating procedure	TBD	Deferred

APPLICATION		NEXT ASSY QTY REQD	REVISIONS			
USED ON	NEXT ASSY		LTR	DESCRIPTION	DATE	APPROVED
QD	X750500	1	A	INCORPORATED ECR #096	85-01-09	[signature]

ENGINEERING RELEASE

JAN 15 1985

Must be maintained current by recipient

APPLICABLE SPECIFICATIONS

THE ABOVE TRW DEFENSE AND SPACE SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED

1. INTERPRET PER MIL STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS:
.XXX ± .010
.XX ± .03
.X ± .1

TOLERANCES ON ANGULAR DIMENSIONS:
MACHINED & LOCATING ± 0°30'
FORMED ± 2°
CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA

FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN	[signature] Connelly	84-06-29
CHECKED	[signature]	84/06/29
ENGINEER	[signature]	84/06/29
	[signature]	85/01/11
	D.A. Kitteri [signature]	84/06/29
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW
DEFENSE AND SPACE SYSTEMS GROUP
ONE SPACE PARK • REDONDO BEACH CALIFORNIA

INDENTURED DRAWING LIST,
PSP - CTM

REV. LTR: A

SIZE	FSCM NO.	
A	11982	X750455

SCALE 1 | CI QD | SHEET 1 OF 13

SYSTEMS 2623 REV. 5-78

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE		ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
X750500	J	1			COMPONENTS TEST MODULE ASSEMBLY-CTM	A
X750346	J	2			SOURCE END ASSY-CTM	
X750459	E	3			N.S. ASSY-CTM	
X752032	D	4			PLATE,N.S.,CU-CTM	A
X744179	E	4			PLATE, URANIUM, ASSEMBLY, 30 CM-CTM	
X750348	D	4			COIL, HEAT EXCHANGER, CTM	
X750349	D	4			HOUSING, INLET, HEAT EXCHANGER - CTM	
X750350	D	4			MANIFOLD, INLET, HEAT EXCHANGER - CTM	
X750351	D	4			TUBE ASSY, INLET, HEAT EXCHANGER - CTM	
X750352	E	4			MANIFOLD ASSY, OUTLET, HEAT EXCHANGER - CTM	
X750353	D	4			SHIELD, HEAT EXCHANGER - CTM	
X750354	C	4			CLAMP, H.V.,HEAT EXCHANGER - CTM	
X750355	E	4			SUPPORT ASSY, HEAT EXCHANGER - CTM	
X750356	C	4			INSULATOR, ALUMINA, HEAT EXCHANGER - CTM	
X750357	C	4			INSERT, HEAT EXCHANGER - CTM	
X750371	D	4			SCREW ASSY, CAPTIVE, HEAT EXCHANGER - CTM	
X750360	E	3			ASSY, LIMITER & DIFFUSER - CTM	
X750361	E	4			DIFFUSER, MICROWAVE - CTM	
X750362	E	4			LIMITER - CTM	
X750363	E	4			RING, SUPPORT, LIMITER -CTM	
X750364	E	4			SHROUD, DIFFUSER - CTM	
X750368	E	3			SCREEN ASSY, MICROWAVE - CTM	
X750369	E	4			SCREEN - CTM	
X750370	E	4			DISC, SUPPORT, SCREEN - CTM	
X750378	E	3			HOOD ASSY, H.V. ENCLOSURE, SEA - CTM	A
X750394	J	3			WATER WING INSTALLATION, SEA - CTM	
X750396	D	4			ANGLE, SUPPORT, FLUID COMPONENTS, SEA - CTM	
X750397	D	4			SUPPORT ASSEMBLY, FLUID COMPONENTS, SEA - CTM	
X750398	J	4			MANIFOLD ASSEMBLY, WATER WING, SEA - CTM	
X747116	E	4			MANIFOLD SUPPORT, WATER WING, CEA - CTM	
X750383	E	3			HOUSING ASSY, HIGH VOLTAGE FEEDTHRU - CTM	
X750384	J	4			HOUSING, HIGH VOLTAGE FEEDTHRU - CTM	
X750385	E	4			FLANGE , HIGH VOLTAGE HOUSING - CTM	
X750386	E	4			COVER, HIGH VOLTAGE HOUSING - CTM	
X750387	E	4			INTERLOCK ASSY, HIGH VOLTAGE - CTM	
X750388	D	4			CLAMP, FLANGE, HIGH VOLTAGE HOUSING - CTM	
X750389	D	4			SCREW, CAPTIVE, HIGH VOLTAGE HOUSING - CTM	
X750390	E	3			CLAMP, HIGH VOLTAGE FEEDTHRU - CTM	
X750391	D	3			CABLE ASSY, H.V.,SEA - CTM	
X750392	J	3			END PLATE, SEA - CTM	
X750372	D	3			FEEDTHRU ASSY, 3/4" TUBE - CTM	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	ORDER OF ASSY (1 2 3 4 5 6 7)	REP. DWG	NOTE	TITLE	IDL REV
T424657	E	3			FLANGE, 47" DIA. BLANKOFF VACUUM SYSTEM, BORE - PPM	A
X750365	C	3			STUD, SUPPORT, HEAT EXCHANGER - CTM	
X750366	C	3			SPACER, HEAT EXCHANGER - CTM	
X750374	J	3			STRUCTURE ASSY, SEA - CTM	
X750375	E	3			SHIELD ASSY, WATER BREAK, SEA - CTM	
X750376	D	3			SHIELD ASSY, H.V. FEEDTHRU, SEA - CTM	
X750377	D	3			CLAMP, WATER BREAK, SEA - CTM	
X750380	D	3			WATER BREAK, H.V.-CTM	
X750381	D	3			HOSE, FLEXIBLE, SEA - CTM	
X750382	E	3			FEEDTHRU, HIGH VOLTAGE - CTM	
X428515	E	3			FLANGE, BLANK-OFF, SEA - CTM	
X429330	D	3			SHUTTER, OPTICAL INTERFER., DIAG. - ECH-10.6/28-PPM	
X419535	E	3			VAC-SEAL 3/4 ASSEMBLY	
X429069	E	3			FLANGE ASSY,OPTICAL INTERFER.,DIAG.-ECH-10.6/28-PPM	
X429089	D	3			WINDOW, OPTICAL INTERFERO., DIAG.-ECH-10.6/28-PPM	
X429335	D	3			WASHER, OPTICAL INTERFERO., DIAG.-ECH-10.6/28-PPM	
X429064	D	3			CRANK ASSY,OPTICAL INTERFERO.,DIAG.-ECH-10.6/28-PPM	
X429334	D	3			PLUG, 3/4" VACUUM SEAL, DIAG.-ECH-10.6/28-PPM	
X750525	E	3			O-RING, BORE - CTM	A
X747162	E	3			PLATE, ADAPTER, CEA/CTM	
X751962	J	3			SHIM PACK, END CHAMBER, CTM	A
X752031	E	3			MOISTURE DETECTOR, SEA END CHAMBER-CTM	A
X750487	J	3			END CHAMBER, CEA/SEA ASSY, CTM	
X426401	J	3			CARRIAGE, END CHAMBER - PPM	
X426829	J	2			TRANSPORTER ASSY, SOURCE - PPM	A
X426400	J	3			FRAME, TRANSPORTER, SOURCE - PPM	A
X426434	E	3			TRAY, TRANSPORTER, SOURCE - PPM	A
X426692	C	3			TUBE, GUIDE, FAILSAFE PIN - PPM	A
X426693	C	3			PIN SLIDER & FAILSAFE - PPM	A
X750499	D	3			RAIL,CARRIAGE, CTM	A
X426699	C	3			SHIELD, JACK, TRANSPORTER - PPM	A
X426822	C	3			SUPPORT, RAIL - PPM	A
X425777	D	3			BRACKET, CASTER, TRANSPORTER - PPM	A
X425779	C	3			BRACKET, LEVELING, TRANSPORTER - PPM	A
X426721	D	3			RAIL, GUIDE, TRANSPORTER - PPM	A
X426722	D	3			BRACKET, LOCATING PIN, TRANSPORTER - PPM	A
X426723	C	3			PIN, LOCATING, TRANSPORTER - PPM	A
X427619	E	3			CRANK, JACK, TRANSPORTER - PPM	A
X427673	E	3			SADDLE, CHAMBER SUPPORT - PPM	A
X428071	D	3			PLATE, PALLET JACK, TRANSPORTER - PPM	A
X426781	D	3			ARM SUPPORT, EXTENSION TRAY, TRANSPORTER - PPM	A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE		ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
X428308	D	3			SUPPORT, WINCH SHAFT - PPM	A
X426782	C	3			JACK, FRONT SUPPORT, TRANSPORTER - PPM	A
X427672	D	3			SHIM, LOCATING PIN, TRANSPORTER - PPM	A
X428306	D	3			CRANK SHAFTS, WINCH	A
X428994	D	3			STOP BLOCK, SEA TRANSPORTER - PPM	A
X426694	D	3			TUBE, GUIDE, SLIDER - PPM	A
X750486	J	3			RETRACTER ASSEMBLY, TRANSPORTER, CTM	
X750490	E	4			FRAME ASSY, RETRACTOR, TRANSPORTER, CTM	
X750491	D	4			PEDESTAL, CABEL, RETRACTER, TRANSPORTER, CTM	
X750492	C	4			CRANK SHAFT, WINCH, RETRACTOR, TRANSPORTER, CTM	
X750493	C	4			TOW BAR, RETRACTER, TRANSPORTER, CTM	
X750494	C	4			CLEVIS BRACKET, RETRACTOR	
X750496	D	4			WHEEL, WINCH, RETRACTOR, TRANSPORTER, CTM	
X750530	C	4			EXTENSION,CRANK SHAFT,WINCH RETRACTER,TRANSPORTER, CTM	
X428308	D	4			SUPPORT, WINCH SHAFT - PPM	
X750498	J	2			VACUUM SYSTEM ASSEMBLY,CTM	A
X747236	J	3			CHAMBER ASSY,VACUUM SYSTEM,BORE-CTM	A
X424661	E	3			ELBOW ASSY,24" DIA. VACUUM SYSTEM,BORE -PPM	A
X425226	E	3			TEE ASSY,ROUGHLINE,VACUUM SYSTEM,BORE-PPM	A
X425228	E	3			ELBOW & TEE ASSY,FORELINE,VACUUM SYSTEM BORE-PPM	A
X425235	E	3			FORELINE ASSY,VACUUM SYSTEM,BORE-PPM	A
X425236	D	3			ROUGHLINE ASSY,VACUUM SYSTEM,BORE-PPM	A
X425238	D	3			HOLDING LINE,2" DIA VACUUM SYSTEM,BORE-PPM	A
X425243	E	3			CONNECTION,6" & 2",VACUUM SYSTEM BORE-PPM	A
X425251	D	3			VALVE,RELIEF,VACUUM SYSTEM,DEWAR-PPM	A
X750525	E	3	R		O-RING,BORE-CTM	A
X425781	D	3			SHIELD,BELLOWS,VACUUM SYSTEM-PPM	A
C750526	E	3			20" DIFFUSION PUMP CVC MODEL 285710 - CTM	A
C750527	E	3			24" TRAP,LN2,TORR-VAC LNB 242,CTM	A
C750528	E	3			24" GATE VALVE TORR-VAC SVL-242,CTM	A
T424659	E	3			FLANGE ASSY,47" DIA PUMP OUT,VACUUM SYSTEM BORE-PPM	A
T424657	E	3	R		FLANGE 47" DIA BLANKOFF,VACUUM SYSTEM,BORE-PPM	A
X750522	D	3			PLATE,ADAPTER,SOLENOID VALVE-CTM	A
X750523	D	3			FLANGE,BLANK-OFF RGA-CTM	A
X424460	D	3			HOUSING, ION GAUGE - PPM	A
X425261	E	3			OIL TRAP, VACUUM PUMP - PPM	A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
X747129	J	2			MAGNET, BORE TUBE, VACUUM CHAMBER ASSY - CTM	A
X747138	E	3			ASSEMBLY, BORE TUBE, CTM	
X747172	E	3			ADAPTER PLATE, BORE TUBE, CTM	
X747139	C	3			CLAMP, BORE TUBE, CTM	
X750525	E	3	R		O-RING, BORE - CTM	
X747140	E	3			UPPER SUPPORT, BORE TUBE, CTM	
X747141	D	3			LOWER SUPPORT, BORE TUBE, CTM	
X747142	D	3			GUIDE BLOCK, BORE TUBE, CTM	
X750532	C	3			SHIM, BLOCK, BORE TUBE - CTM	
X750484	D	3			SKID PAD, BORE TUBE, CTM	
T747184	E	3			LOWER PLATE, TEMPORARY SUPPORT - CTM	
T747185	C	3			BLOCK, TEMPORARY SUPPORT, CTM	
T747186	E	3			UPPER PLATE, TEMPORARY SUPPORT - CTM	
T747187	E	3			SUPPORT, TEMPOPARY, CTM	
X750517	E	3			BRACKET, MAGNET - CTM	
X747219	E	3			SHIM, MAGNET - CTM	
X750402	C	3			C-SHIM, VACUUM CHAMBER, CTM	
X750393	C	3			JACK BOLT, VACUUM CHAMBER, CTM	
X750373	C	3			PRESSURE PAD, VACUUM CHAMBER, CTM	
X747181	J	3			STAND MAGNET, CTM	
X747182	J	3			STAND CHAMBER, VACUUM SYSTEM, CTM	
X747183	J	3			STAND BORE TUBE, CTM	
X747236	J	3	R		CHAMBER ASSY, VACUUM SYSTEM, BORE - CTM	A
E960255	E	3		1	MAGNET, MODEL SCM 100-15	
X750433	E	2			INSTALLATION PROCEDURE, BORE TUBE - CTM	A
T750434	E	3			SUPPORT ASSY, BORE-TUBE INSTL. - CTM	A
T750435	E	3			SUPPORT STAND ASSY, BORE-TUBE INSTL. - CTM	A
T750436	E	3			ADJUSTMENT PLATE, BORE-TUBE INSTL. TOOL - CTM	A
T750437	E	3			BEAM, BORE-TUBE INSTL. - CTM	A
T750438	E	3			SPACER, BORE-TUBE INSTALLATION TOOL - CTM	A
T747220	D	3			PLATE, INSTALLATION TOOL, BORE-TUBE - CTM	A
X747219	E	3			SHIM, MAGNET - CTM	A
X747218	J	2			COOLING MANIFOLD INSTALLATION, BORE TUBE ASSY - CTM	
X747174	J	3			MANIFOLD ASSY, BORE TUBE COOLING SYSTEM - CTM	
X747175	E	3			BRACKET SUPPORT, COOLING MANIFOLD - CTM	
X747173	C	4			HOSE ASSY, BORE TUBE COOLING MANIFOLD - CTM	A
X747171	E	4			BRACKET SUPPORT, FLOW CONTROL/METERING ASSY - CTM	A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	1	2	3	4	5	6	7	REP. DWG	NOTE	TITLE	IDL REV.
X750454	D				4						FLOW METERING/CONTROL ASSY	A
X747110	J		2								SEAL-VAC SYSTEM,CTM	A
X750423	E		2								STAND GYROTRON - CTM	
X750424	D			3							MOUNTING PLATE, GYROTRON STAND - CTM	
X750425	C			3							BRACKET, GYROTRON STAND - CTM	
X750431	C		2								MOUNTING PLATE, WATER LOAD - CTM	A
X751957	E		2								WATER LOAD SUPPORT STRUCTURE ASSY - CTM	
X751948	D			3							GASKET, SHIVELY FLANGE, CTM	
X751953	J				4						ADAPTER, CTF/SHIVELY, CTM	
T751947			2								TOOLING, WAVEGUIDE, ALIGNMENT - CTM	
X750410	D		2								SUPPORT ASSY, STRONG BACK - CTM	
X750439	D		2								BRACKET, STRONG BACK - CTM	
X750440	D		2								RIGID CLAMP ASSY, WAVEGUIDE - CTM	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE / TITLE	IDL REV
X750441	E	2		CLAMP, SPRING LOADED ASSY, WAVEGUIDE - CTM	
X750432	E	2		STRONG BACK ASSY, WAVEGUIDE - CTM	
X750453	E	3		BEAM ASSY, STRONGBACK - CTM	
X747231	C	3		FLAT PLATE, STRONG BACK - CTM	
X747233	C	3		END PLATE, STRONG BACK - CTM	
X750408	E	2		2.5" WAVEGUIDE ASSY - CTM	
X751948	D	3	R	GASKET, SHIVELY FLANGE, CTM	
X751980	E	3		SECTION, 2.5" WAVEGUIDE - CTM	A
X751950	D	4		COLLAR, SHIVELY FLANGE, CTM	
X751949	D	4		FLANGE, SHIVELY ROTATABLE, CTM	
X750456	E	4		TUBE, 2.5" WAVEGUIDE - CTM	
X751950	D	5	R	COLLAR,SHIVELY FLANGE,CTM	A
X751979	D	3		ADAPTER, 2.5" WAVEGUIDE - CTM	A
X751950	D	4	R	COLLAR, SHIVELY FLANGE, CTM	
X751949	D	4	R	FLANGE, SHIVELY ROTATABLE, CTM	
X751943	E	4		FLANGE,SCREW TYPE,PPM	A
X751932	E	3		ELBOW ASSY. 2.5" WAVEGUIDE, CEA/CTM	
X751913	E	4		ELBOW,MACHINED,CTM	A
X751949	D	4	R	FLANGE,SHIVELY ROTATABLE,CTM	A
X751950	D	4	R	COLLAR,SHIVELY FLANGE,CTM	A
X747209	J	5		ELBOW,WAVEGUIDE,CTM	A
X750420	J	2		L.P. PANEL INSTL,GYRO COOLING-CTM	A
X750421	J	2		H.P. PANEL INSLT,GYRO COOLING-CTM	A
X750412	J	3		L.P. PANEL ASSY, GYROTRON COOLING - CTM	
X750413	J	3		H.P. PANEL ASSY, GYROTRON COOLING - CTM	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	1	2	3	4	5	6	7	REP. DWG	NOTE	TITLE	IDL REV
X750414	E			3							MANIFOLD ASSY, WAVEGUIDE, GYROTRON COOLING - CTM	
X750415	J			3							L.P. MANIFOLD ASSY, GYROTRON COOLING - CTM	
X750416	J			3							H.P. MANIFOLD ASSY, GYROTRON COOLING - CTM	
X750417	E			3							L.P. FRAME ASSY, GYROTRON COOLING -CTM	
X750418	E			3							H.P. FRAME ASSY, GYRO. COOLING - CTM	
X750419	J			3							DRIP PAN ASSY, GYRO. COOLING - CTM	
X750452	E			3							MANIFOLD SUPPORT, GYRO COOLING - CTM	
X747230	E			3							BRACKET, FRAME ASSY, GYRO COOLING - CTM	
X751958	E			3							ADAPTER FITTING, GYRO COOLING - CTM	
X426724	C		2								CUP,LOCATING & FAILSAFE PIN,TRANSPORTER-PPM	A
X426723	C		2								PIN,LOCATING,TRANSPORTER-PPM	A
X425772	D		2								GUIDE ROLLER ASSY,TRANSPORTER -PMS	A
X750367	E		2								INSULATOR, GYROTRON - CTM	
X750403	J		2								DRAIN/ARGON INJECTION SYSTEM - CTM	
X750404	E			3							FLANGE, DRAIN/ARGON	
X747130	J		2								COLLECTOR END ASSY,MODULE ASSY,CTM	A
X747143	J			3							WATER WING INSTL. CEA END, CEA/CTM	
X747116	E				4				R		MANIFOLD, SUPPORT CEA/CTM	
X747117	J				4						MANIFOLD ASSY, WATER WING, CEA/CTM	
X751929	J			3							INSTALLATIN, SEAL-VAC & GN2, CEA/CTM	
X751928	J				4						MANIFOLD, SEAL-VAC & GN2	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
X425251	D	4			VALVE, RELIEF, VACUUM SYSTEM, DEWAR - PPM	
X750487	J	3	R		END CHAMBER, CEA/SEA ASSY, CTM	
X747162	E	3	R		PLATE, ADAPTER, CEA/CTM	
X747114	J	3			END PLATE, CEA/CTM	
X428503	E	3			CHANGE-OUT CHAMBER,10CM COLLECTOR,CEA	
X428074	E	3			VALVE ADAPTER, CHANGE-OUT CHAMBER - CEA	
X747144	J	3			GATE VALVE, CHANGE-OUT CHAMBER - CEA	
X751914	J	3			TUBE, CONTAINMENT, CEA/CTM	
X747503	E,J	4			TRACK ASSY,PROBE SHAFT,CEA/CTM	
X747149	E	3			BAYONET, COOLANT, CEA/CTM	
X428099	D	3			SHAFT, ACTUATOR DOOR TERMINATION PLATE - CEA	
X418698	C	4			TUBE, PROBE	
X428098	C	3			INSULATOR,ACTUATOR SHAFT,TERMINATION PLATE-CEA	
X428260	D	3			HANDLE,ACTUATOR DOOR,TERMINATION PLATE-CEA	
X428301	D	3			BRACKET,ACTUATOR SHAFT,TERMINATION PLATE-CEA	
X750525	E	3	R		O-RING, BORE - CTM	A
X744943	D	3			PRE-AMP ASSY	A
X744944	D	4		2	CIRCUIT BOARD LAYOUT,PRE-AMP	A
X744936	D	4		2	SCHEMATIC DIAGRAM,PRE-AMP	A
X751962	D	3	R		SHIM PACK END CHAMBER CTM	A
X751917	D	3			SUPPORT, PROBE SHAFT, CEA/CTM	
X747152	E	3			BRACKET,SUPPORT,CONTAINMENT TUBE,CEA/CTM	
X419535	E	3	R		VAC-SEAL 3/4" ASSEMBLY	
X747154	J	3			SUPPORT FRAME, TERM. PLATE, CEA/CTM	
X750502	J	3			SUPPORT ASSY. PROBE SHAFT, CEA/CTM	
X428515	E	3	R		BLANKOFF, FLANGE, DIAGNOSTICS - PPM	
X747132	J	3			PROBE SHAFT ASSY, FLUX BOX PROBE, DIAGNOSTICS/CTM	
X747131	J	3			PROBE SHAFT ASSY, LANGMUIR PROBE, DIAGNOSTICS/CTM	
X425816	D	3			SHAFT SUPPORT, Z & O PROBE DRIVE - CEA	
X732620	E	3			SUPPORT, O-DRIVE MAGIC COIL, DIAGNOSTICS - PSP	
X747155	E	3			PLATE, MOUNTING, THETA DRIVE, CEA/CTM	
X429089	D	3	R		WINDOW,OPTICAL INTERFERO.DIAG.ECH-10.6/20 PPM	
X429069	E	3	R		FLANGE ASSY,OPTICAL INTERFER.,DIAG-ECH-10.6/20 PPM	
X525810	E	3			SUPPORT BRACKET, Z & O PROBE DRIVER - CEA	
X747145	J	3			TERM. PLATE ASSY, CEA ASSY, CEA/CTM	
X747147	J	4			BARN DOOR,TERMINATION PLATE,CEA/CTM	
X750542	D	4			ARBOR,DOOR,TERMINATION PLATE,CEA/CTM	
X750543	D	4			SLEEVE,BEARING,TERMINATION PLATE,CEA/CTM	
X428091	D	4			YOKE,DOOR,TERMINATION PLATE-CEA	
X428092	E	4			ADAPTER,COOLANT & ACTUATOR SHAFT,TERM.PLATE,CEA	
X428096	D	4			STOP,DOOR,TERMINATION PLATE-CEA	
X747161	J	4			FACE PLATE ASSY, TERMINATION PLATE, CEA/CTM	
X751909	D	4			FITTING, VALVE, CEA/CTM	
X751912	D	5			GLAND,SQUARE TUBE,CEA/CTM	
X751911	J	4			TUBE, STUB, TERMINATION PLATE, CEA/CTM	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE		ORDER OF ASSY 1	2	3	4	5	6	7	REP. DWG	NOTE	TITLE	IDL REV
X751909	D					5			R		FITTING, VALVE, CEA/CTM	
X747146	J				4						MANIFOLD, TERMINATION PLATE, CEA/CTM	
X751910	D					5					BOSS, SAE THREADED, CEA/CTM	
X751918	E				4						HANGER, TERMINATION PLATE, CEA/CTM	
X751919	D				4						COLLAR, TERMINATION PLATE, CEA/CTM	
X747212	E			3							SUPPORT, WAVEGUIDE, CEA/CTM	
X747206	J			3							LAUNCHER ASSY,WAVEGUIDE,CEA/CTM	
X747213	D				4						FLANGE, WAVEGUIDE, CTM	
X747209	J				4						ELBOW, WAVEGUIDE, CTM	
X747207	J			3							FEEDTHRU ASSY, WAVEGUIDE, CEA/CTM	
X747213	D				4				R		FLANGE, WAVEGUIDE, CTM	
X751949	D				4				R		FLANGE, SHIVELY ROTATABLE, CTM	A
X751950	D				4				R		COLLAR, SHIVELY FLANGE, CTM	A
X751932	E			3					R		ELBOW ASSY, WAVEGUIDE, CEA/CTM	
X751913	E				4				R		ELBOW,MACHINED,CTM	A
X751949	D				4				R		FLANGE, SHIVELY ROTATABLE, CTM	A
X751950	D				4				R		COLLAR, SHIVELY FLANGE, CTM	A
X747209	J					5			R		ELBOW, WAVEGUIDE, CTM	
X751948	C			3					R		GASKET, SHIVELY FLANGE, CTM	A
X751952	D			3							GASKET, SINGLE-DISK WINDOW, CTM	A
X426829	J			3					R		TRANSPORTER ASSY,SOURCE-PPM	
X426401	J			3					R		CARRIAGE,END CHAMBER-PPM	
X750486	J			3					R		RETRACTOR ASSEMBLY,TRANSPORTER,CTM	
X751954	E			3							FLEX SECTION MOD,WAVEGUIDE,CTM	A
X751953	J				4				R		ADAPTER,CTF/SHIVELY,CTM	A
X750535	D			3							INSERT,ARC DETECTOR PLUG,CEA/CTM	
X750536	D			3							CAP,ARC DETECTOR PLUG,CEA/CTN	
X750537	D			3							GASKET,ARC DETECTOR PLUG,CEA/CTM	
X750538	D			3							CIRCUIT BLOCK,ARC DETECTOR PLUG,CEA/CTM	
X750540	D			3							HOUSING,ARC DETECTOR PLUG,CEA/CTM	
X750541	D			3							FLANGE,BNC FEEDTHRU PLUG,CEA/CTM	
X747210	D			3							RF GASKET,BNC FEEDTHRU,CEA/CTM	
T751933	E	END ITEM									ADAPTER,WATER DROP,CEA/CTM	
T751934	J	END ITEM									FIXTURE,FLOW CHECK,CEA/CTM	
X747132	J			3					R		PROBE SHAFT ASSY,FLUX BOX PROBE,DIAGNOSTICS/CTM	
X427620	D				4						1 1/2" O SEAL ASSY,PPM DIAGNOSTICS	
X427622	D					5					FLANGE, 1 1/2" O SEAL ASSY	A
X427623	C					5					RING, 1 1/2" SEAL ASSY	A-
X427624	C					5					SPACER, 1 1/2" O SEAL ASSY	A
X427625	C					5					SCREW, 1 1/2" SEAL ASSY	A
X427636	D					5					SLEEVE, 1 1/2" O SEAL ASSY	A
X427638	C					5					PLATE,BEARING,1 1/2" O SEAL ASSY	A
X427661	E				4						SUPPORT HEAD,PROBE DIAGNOSTICS-PPM	
X427648	E				4						SHAFT ASSY,PROBE,DIAGNOSTICS-PPM	
X427674	D					5					END FITTING,SHAFT,DIAGNOSTICS-PPM	A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO.	/SIZE	1	2	3	4	5	6	7	REP. DWG	NOTE	TITLE	IDL REV
X427675	C					5					RETAINING NUT,SHAFT,DIAGNOSTICS-PPM	A
X427677	C					5					PLUG,SHAFT,DIAGNOSTICS-PPM	A
X427678	C					5					JAM NUT,SHAFT,DIAGNOSTICS-PPM	A
X427683	C					5					WASHER,SHAFT,DIAGNOSTICS-PPM	A
X427679	D					5					TUBE, 1 1/2" O DIAGNOSTICS-PPM	A
X422629	C						6				TUBE, 1 1/2" PROBE SHAFT	A
X427680	D					5					TUBE, 1" O DIAGNOSTICS-PPM	A
X427681	D					5					TUBE, 1/2" DIAGNOSTICS-PPM	A
X427682	C					5					GASKET,PROBE SHAFT,DIAGNOSTICS-PPM	A
X427646	C				4						SLEEVE,BRAZING,DIAGNOSTICS-PPM	
X747156	D				4						FLUX BOX ASSY, PROBE SHAFT ASSY, DIAGNOSTICS/CTM	
X747157	D					5					TUBE ASSY, FLUX BOX, DIAGNOSTICS/CTM	
X423302	C					5					LINER/PLUG, FLUX BOX	
X747158	D					5					BASE PLATE,FLUX BOX,DIAGNOSTICS/CTM	
X428568	D				4						GAGE CLAMP,PROBE SHAFT,DIAGNOSTICS-PPM	
X429628	E				4						VACUUM FIXTURE ASSY,PROBE SHAFT-DIAGNOSTICS-PPM	
X747163	D				4						NOSE CONE, PROBE HEAD, DIAGNOSTICS/CTM	
X747160	E				4						ENDPLATE,CHANGE-OUT CHAMBER,DIAGNOSTICS/CTM	
X429089	D				4				R		WINDOW,OPTICAL INTERFERO.,DIAG. ECH-10.6/20-PPM	
X429069	E				4				R		FLANGE,ASSY,OPTICAL INTER.,DIAG.ECH-10.6/28-PPM	
X747151	D				4						FITTING,BEARING,DIAGNOSTICS/CTM	
X419535	E				4				R		VAC-SEAL,3/4" ASSEMBLY	
X429064	E				4				R		CRANK ASSY,OPTICAL INTERFERO.,DIAG.-ECH-10.6/28-PPM	
X429334	D				4				R		PLUG, 3/4" VACUUM SEAL, DIAG.-ECH-10.6/28-PPM	
X429335	D				4				R		WASHER,OPTICAL INTERFERO. DIAG.-ECH-10.6/28-PPM	
X429330	C				4				R		SHUTTER, OPTICAL INTERFER., DIAG.-ECH	A
X747131	J			3					R		PROBE SHAFT ASSY,LANGMUIR PROBE,DIAGNOSTICS/CTM	
X427620	D				4				R		1 1/2" O SEAL ASSY PPM DIAGNOSTICS	
X427622	D					5			R		FLANGE, 1 1/2" O SEAL ASSY	A
X427623	C					5			R		RING, 1 1/2" O SEAL ASSY	A
X427624	C					5			R		SPACER, 1 1/2" O SEAL ASSY	A
X427625	C					5			R		SCREW, 1 1/2" O SEAL ASSY	A
X427636	D					5			R		SLEEVE, 1 1/2" O SEAL ASSY	A
X427638	C					5			R		PLATE, BEARING 1 1/2" O SEAL ASSY	A
X427661	E				4				R		SUPPORT HEAD,PROBE DIAGNOSTICS-PPM	
X427646	C				4				R		SLEEVE,BRAZING,DIAGNOSTICS-PPM	
X428264	E				4						WAND ASSY,TERMINATION PROBE,DIAGNOSTICS-PPM	
X428312	D					5					FLANGE,PROBE WAND,DIAGNOSTICS-PPM	
X428313	C					5					MATING RING,WAND,DIAGNOSTICS-PPM	
X428314	C					5					PLUG,WAND DIAGNOSTICS-PPM	
X428311	D					5					NEEDLE VALVE ASSY,PROBE ARM,DIAGNOSTICS-PPM	
X427690	E					5					SENSOR ASSY,REA/LANGMUIR DIAGNOSTICS-PPM	
X428297	E						6				ELECTRODE BARREL ASSY,REA/LANGMUIR SENSOR-PPM	
X428316	E						6				BOAT & COVER,REA/LANGMUIR SENSOR,DIAGNOSTICS-PPM	
X428317	D						6				STEM,REA/LANGMUIR SENSOR-PPM	

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE		ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV.
X428568	D	4	R		GAGE CLAMP,PROBE SHAFT,DIAGNOSTICS-PPM	
X427600	J	4			PROBE DRIVE ASSY,0 MOTION,PROBE DRIVE-PPM	
X747163	D	4	R		NOSE CONE,PROBE HEAD,DIAGNOSTICS/CTM	
X428298	D	4			SHIELD,SENSOR,DIAGNOSTICS-PPM	
X429628	E	4	R		VACUUM FIXTURE ASSY,PROBE SHAFT,DIAGNOSTICS-PPM	
X427600	J	5			PROBE DRIVE ASSY, 0 MOTION PROBE DRIVE - PPM	
X427601	E	5			GEAR HOUSING, 0 MOTION PROBE DRIVE - PPM	
X427602	E	5			SHAFT HOUSING, 0 MOTION PROBE DRIVE - PPM	
X427603	D	5			DRIVE SHAFT,WORM,0 MOTION PROBE DRIVE-PPM	
X427604	D	5			SHAFT,PROBE DRIVER,0 MOTION PROBE DRIVE-PPM	
X427605	D	5			END PLATE,0 MOTION PROBE DRIVE-PPM	
X427606	C	5			BEARING,END PLATE,0 MOTION PROBE DRIVE-PPM	
X427607	C	5			BEARING,GEAR HOUSING,0 MOTION PROBE DRIVE-PPM	
X427608	C	5			LOCK RING,GEAR,0 MOTION PROBE DRIVE-PPM	
X427609	C	5			GEAR,PROBE DRIVER,0 MOTION PROBE DRIVE-PPM	
X427610	C	5			MOUNTING BRACKET,MICRO-SWITCH,0 MOTION PROBE DRIVE PPM	
X427611	D	5			STOP,FIXED,0 MOTION PROBE DRIVE-PPM	
X427612	D	5			STOP,ADJUSTABLE,0 MOTION PROBE DRIVE-PPM	
X427613	D	5			CLAMP ASSY,0 MOTION PROBE DRIVE-PPM	
X427614	D	5			PLATE,MOTOR MOUNT,0 MOTION PROBE DRIVE-PPM	
X427615	C	5			MOTOR MOUNT ASSY,0 MOTION PROBE DRIVE-PPM	
X427616	C	5			SHIM,GEAR,0 MOTION PROBE DRIVE-PPM	
X427617	C	5			WASHER,DRIVE SHAFT,0 MOTION DRIVE-PPM	
X427618	C	5			SPACER,DRIVE SHAFT,0 MOTION PROBE DRIVE-PPM	
X427641	E	5			MOTOR,SHIELD ASSY,0 MOTION PROBE DRIVE-PPM	
X427640	D	6			FLANGE,MOTOR SHIELD,0 MOTION PROBE DRIVE-PPM	
X427685	C	5			PULLEY,WORM DRIVE,0 MOTION PROBE DRIVE-PPM	
X421377	D	5			COUPLING,FLEXIBLE	
X427648	E	4	R		SHAFT ASSY,PROBE,DIAGNOSTICS-PPM	
X427674	D	5	R		END FITTING,SHAFT,DIAGNOSTICS-PPM	
X427675	C	5	R		RETAINING NUT,SHAFT,DIAGNOSTICS-PPM	
X427677	C	5	R		PLUG,SHAFT,DIAGNOSTICS-PPM	
X427678	C	5	R		JAM NUT,SHAFT,DIAGNOSTICS-PPM	
X427683	C	5	R		WASHER,SHAFT,DIAGNOSTICS-PPM	
X427679	D	5	R		TUBE,1 1/2" 0,DIAGNOSTICS-PPM	
X422629	C	6	R		TUBE,1 1/2" PROBE SHAFT	
X427680	D	5	R		TUBE,1" 0,DIAGNOSTICS-PPM	
X427681	D	5	R		TUBE,1/2" DIAGNOSTICS-PPM	
X427682	C	5	R		GASKET,PROBE SHAFT,DIAGNOSTICS-PPM	
T428481	E	END ITEM			TEST FIXTURE,REA/LANGMUIR WAND,DIAGNOSTICS-PPM	
T732549	E	END ITEM			FIXTURE,LEAK CHECK,VACUUM SEAL,DIAGNOSTICS-PSP	
T418729	C	END ITEM			FACE SPANNER	
T751960	D	END ITEM			WAVEGUIDE,LEAK CHECK FIXTURE,CTM	
						A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE		ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
X750544	J	FOR REFERENCE			INTERFACE CONTROL,CTM CEA/DIAGNOSTICS SRL/TRW	A
X744187	J	FOR REFERENCE			SERVICE FLOOR PLAN-CTM	A
X750731	E	2		2	DATA AQUISITION AND CONTROL CENTER,ASSEMBLY	A
X750629	E	2		2	PANEL "A" ENCLOSURE,DATA ACQUISITION AND CONTROL CENTER	A
X750748	E	2		2	STAND,GYROTRON MAGNET POWER SUPPLY INSTALLATION	A
X750640	D	2		2	INTERFACE PANEL,ENCODER/STEPPER DRIVER PROBE POSITION CONTROLLER	A
X750744	E	2		2	CEA JUNCTION BOX, COMPONENT TEST MODULE	A
X750620	E	2		2	FC-75 FLOW CURCUIT,GYROTRON WINDOW	A
X750625	J	2		2	ASSEMBLY-PILOT SOLENNOID VALVE PANEL,PNEUMATIC CONTROL SUB-SYSTEM	A

EEL MECHANICAL ENGINEERING DEPARTMENT

IDL:	REV:	PGM:	CONFIGURED ITEM:
X750455	A	PSP	CTM

DWG. NO. /SIZE	ORDER OF ASSY 1 2 3 4 5 6 7	REP. DWG	NOTE	TITLE	IDL REV
HP-23S	2		2	MAGNET FIELD MONITOR SENSOR	A
X750655 D	2		2	ASSEMBLY,LN2 SENSOR	A
				NOTE 1. I.G.C. DRAWING NUMBER	
				NOTE 2. LOWER LEVEL IDL'S CONTROLLED BY EEL ELECTRICAL ENGINEERING DEPARTMENT	

APPLICATION		NEXT ASSY QTY REQD
USED ON	NEXT ASSY	
CTM	X750500	1

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

ELECTRICAL DWG - 149/1535

ENGINEERING RELEASE

FEB 04 1985

Must be maintained current by recipient AER

APPLICABLE SPECIFICATIONS

THE ABOVE TRW DEFENSE AND SPACE SYSTEMS GROUP SPECS FORM A PART OF THIS DRAWING

FINISH

HEAT TREAT

UNLESS OTHERWISE SPECIFIED

1. INTERPRET PER MIL-STD-100.
2. DIMENSIONS ARE IN INCHES
3. SURFACE TEXTURE SHALL BE ✓
4. DIMENSIONS APPLY BEFORE PLATING OR CONVERSION COATING.
5. REMOVE BURRS & SHARP EDGES

TOLERANCES ON DECIMAL DIMENSIONS:
.XXX ± .010
.XX ± .03
.X ± .1

TOLERANCES ON ANGULAR DIMENSIONS:
MACHINED & LOCATING ± 0°30'
FORMED ± 2°
CHAMFERS ± 5°

TOLERANCES - ALL HOLE DIA		
FROM	THRU	TOL.
UNDER	.0140	+.0020 −.0005
.0145	.125	+.004 −.001
.126	.250	+.005 −.001
.251	.500	+.006 −.001
.501	.750	+.008 −.001
.751	1.000	+.010 −.001
1.001	2.000	+.012 −.001
OVER	2.000	+.015 −.005

DO NOT SCALE DRAWING

CONTRACT NO.

DRAWN	J. Mesch	85/2/1
CHECKED	A. Reynolds	85/2/1
ENGINEER	A. Reynolds	85/2/1
	J. Dorman	85/2/1
	N. Roy	85/2/1
OTHER APPROVALS		

THE FOLLOWING EO'S HAVE BEEN ATTACHED TO THIS PRINT

TRW
DEFENSE AND SPACE SYSTEMS GROUP
ONE SPACE PARK · REDONDO BEACH, CALIFORNIA

INDENTURED DRAWING LIST
CTM

REV. LTR: N/C

SIZE	FSCM NO.	
A	11982	X750738

SCALE 1 | CI QD | SHEET 1 OF 9

SYSTEMS 2623 REV. 5-78

DRAWING NO.	Rep Dwg.	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750500		J	1							Module Assy - CTM
X750631		E		2						Layout, Data Acquisition Control Center
X750657		E			3					Assembly, 2.00 Coax Patch Panel (3B)
X750658		D			3					Assembly, 1.75 Coax Patch Panel (5E)
X750632		D			3					Assembly, Panel B, Data Acquisition Control Center
X750676		C			3					Plate, Cabinet Numbers, Data Acquisition Control Cente
X744939		E			3					Assembly, Chassis, LN2 Controller
X744927		D				4				Front Panel, Assembly, LN2 Controller
X723671		C					5			LN2 Controller Mounting Plate
X723673		C				4				Vent Grille
X744938		E				4				Schematic, LN2 Controller
X750652		D				4				Rear Panel, LN2 Controller
X750654		E				4				Cryomiser Modified, LN2 Controller
X744934		D				4				Plate Mounting, Relay and Socket Card, LN2 Control Subsystem
X744918		E			3					Control Chassis, Assy, Langmuir Probe Bias Controller
X744916		D				4				Front Panel, Langmuir Probe Bias Unit
X744919		D				4				Board Layout, Ramp Generator and Misc. Electronics, Langmuir Probe Bias Unit
X744920		D				4				Board Layout, D/A. Converter Langmuir Probe Bias Unit
X744921		E				4				Board Layout & Assy, YB Generator Langmuir Probe Bias Unit
X744922		E				4				Board Layout and Assy Preamp Langmuir Probe Bias Unit
X744926		J				4				Schematic Diagram, Langmuir Probe Bias Unit
X744948		E				4				Top Cover Assy, Langmuir Probe Bias Controller
X750666		E			3					Assembly, Probe Position Controller

INDENTURED DRAWING LIST

PROGRAM: PSP
CONFIGURED ITEM: CTM

DRAWING NO.	Rep Dwg.	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750672		E				4				Assembly, Card Cage, Probe Position Controller
X723706		D					5			Edge Card Connector, Subassembly
X750664		D					5			Details, Card Cage, Probe Position Controller
X723718		D				4				Vent Grille - Probe Controller
X723696		C				4				Cover, Rear-Probe Position Controller
X750667		D				4				Front Panel Assembly - Probe Position Controller
X744917		F					5			Detail - Front Panel, Probe Position Controller Panel
X750634		D					5			Silkscreen, Front Panel - Probe Position Controller
X750677		E				4				Side Panels, Probe Position Control
X750679		E				4				Chassis Plate, Probe Position Control
X750680		D				4				Power Supply Plateform, Probe Position Control
X750665		D				4				Rear Panel - Probe Position Controller
X723684		E				4				Bottom Cover Probe Controller
X723699		E				4				Top Cover - Probe Controller
X750635		J				4				Schematic Diagram, Chassis Interconnection, Probe Position Controller
X750636		E					5			Schematic Diagram, Logic, Probe Position Controller
X750637		E					5			Schematic Diagram, A or B Logic Board, Probe Position Controller
— X750639			REF DRAWING							System Diagram, Probe Position Controller
X750618		E			3					Assembly, Gyrotron Magnet Control and Interlocks Panel
X750663		D				4				Rear Panel, Lower, Assembly, Gyrotron Magnet Control and Interlocks Panel
X750669		D					5			Rear Panel, Lower, Gyrotron Magnet Control and Interlocks Panel
X750668		D				4				Bottom Cover, Gyrotron Magnet Control and Interlocks Panel
X750670		D				4				Chassis Side, Gyrotron Magnet Control and Interlocks Panel

DRAWING NO.	Rep Dwg.	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750671		E				4				Chassis Plate, Gyrotron Magnet Control and Interlocks Panel
X750673		E				4				Panel, Upper Rear, Assembly - Gyrotron Magnetic Control and Interlock Panel
X750732		D					5			Back Plate, Filler, Gyrotron Interlocks and Control Panel
X750606		E				4				Schematic and Wiring Diagram, Gyrotron Magnet Control and Interlock Panel
X750607		E					5			Schematic Diagram, Main and Gun Magnet Control and Monitor
X750608		E					5			Component Layout, PCB, Main and Gun Magnet Control and Monitor
X750609		E					5			Schematic Diagram, Magnet Power Control System PB13 and System Wiring
X750610		E					5			Circuit Board Layout, Magnet Power and Control System
X750611		D					5			Schematic Diagram, Gyrotron Collector Magnet Current Monitor Card
X750612		E					5			Circuit Board Layout, Gyrotron Collector Magnet Current Monitor Card
X750613		D					5			Schematic Diagram, Spare Fault Input/Output Card Gyro Interlock and Control (PB-11)

INDENTURED DRAWING LIST

PROGRAM: FSP
CONFIGURED ITEM: CTM

DRAWING NO.	Rep Dwg.	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750614		E					5			Circuit Board Layout, Spare Fault Input/ Output Card, Gyro Interlock and Control
X750615		D					5			Schematic Diagram, 15 Channel Latch Card (PB8,9,10), Gyro Interlock and Control
X750616		E					5			5 Channel Latch Card, Gyrotron Interlock and Magnet Control
X721043		J			3					Gas Injection Controller, Assembly Drawing
X721049		D		REF DRAWING						Component Layout - Gas Injection Controller
X721044		D				4				Gas Injection, Front Panel
X721045		D					5			Silkscreen Mask, Gas Injection Control
X721047	R	D				4				Chassis, Cover
X721048	R	C				4				Chassis, Side
X744924		E				4				CTM - Gas Injection Controller, Schematic Diagram
X721056		E			3					Seal Vacuum Controller, Assembly
X721057		D				4				Seal Vacuum Controller, Front Panel
X721058		C					5			Control Panel Layout, Seal Vacuum
X744925		E				4				CTM- Schematic Seal Vacuum Controller
X721059		D				4				Chassis, Back Panel, Seal Vacuum Controller
X721048	R	C				4				Chassis, Side
X721047	R	D				4				Chassis, Cover
X750641		E			3					Neutral Source Ampere Hr. Meter
X750682		D				4				Front Panel, Neutral Source Amp Hour Meter
X750681		D					5			Silkscreen, Front Panel, Neutral Source Amp Hour Mete
X750690		C				4				Bracket, Neutral Source Amp Hour Meter
X744946		E			3					Chassis Assembly, TRW Arc Detector
X744940		D	REF DRAWING							System Layout, Vacuum Window Arc Detectors
X744947		E				4				Circuit Board Layout, TRW-Arc Detector Control
X744935		E				4				Schematic Diagram, TRW-Arc Detector Control
X750623		C				4				Bracket, Edge-Card Conn. Mtg.
X744945		D				4				Silkscreen, Front Panel, TRW Arc Detector Chassis
X721034		E			3					Bore Vacuum Controller, Assembly
X750643			REF DRAWING							System Diagram, Bore Vacuum Controls

INDENTURED DRAWING LIST

PROGRAM: PSP
CONFIGURED ITEM: CTM

DRAWING NO.	Rep Dwg	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X721031		E				4				Bore Vacuum Controller, Front Panel
X721033		D					5			Silkscreen Mask, Front Panels
X721035		E				4				Chassis, Bore Vacuum Controller
X721036		C				4				Relay Socket Plate, Bore Vacuum Controller
X721037		E				4				Cover, Bore Vacuum Control
X721078		E				4				Schematic, Bore Vacuum Controller
X721038		E			3					Bore Vacuum Monitor, Assembly
X721032		E				4				Bore Meter Relay, Front Panel
X721033		D					5			Silkscreen Mask, Front Panels
X721051		D				4				Vent Grille, Bore Vacuum Monitors
X721039		D				4				Chassis Plate, Bore Vacuum Monitor
X721040		D				4				Rear Panel, Bore Vacuum Monitor
X744914		J				4				Schematic, Bore Vacuum Monitor
X744923		E			3					Panel Layout, CTM System Level Interlock
X744937		E				4				Terminal Designation Diagram, System Level Interlock
										RONAN REFERENCE DRAWINGS
13-2181-C3										Dimensional Drawing
13-2181-C2										Rear Terminal and External Wiring
13-2181-D1										Internal Wiring
13-2181-C4										Plug-in Pushbutton Module
13-2181-C5										Schematic X12 Filter
SS2168										Schematic, Option Board/Aux/115 VAC
SS2072										Auxiliary Contact Module
SS2072										Ground Detection Module
SS204										Flasher Horn Driver
SS2014										Solid State Annunciators Plug-in Lamp Module
X50-1003										Schematic, Single and Dual Setpoint Plug-in Trip Modules
X2-229										Sonalert
X12D380										Wiring Power Supply 24 VDC-1000 W

DRAWING NO.	Rep Dwg	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750644		E			3					Chassis Layout, 24 and 5 Volt Power Supply
X750695		E				4				Cover, Top, 24 and 5 Volt Power Supply
X744932		D			3					Front Panel Layout Central Alarm Subsystem CTM
X744933		D				4				Terminal Designation Diagram Central Alarm Sub-system-CTM
										RONAN REFERENCE DRAWINGS
13-2732-C1										Dimensional Drawing
13-2732-C2										Rear Terminal Arrangement
13-2732-C3										Internal Wiring
13-2732-C4										Series X1 Plug-in Pushbutton Module
13-2732-C5										Schematic X1Z Filter
SS2204										Flasher Horn Driver FHD24
SS2168										Schematic Option Board/Aux/114 VAC
SS2027										Ground Detection Module
X2-229										Sonalert
X12C187										Schematic Power Supply, 24 VDC, 1000 W
X12D380										Wiring, Power Supply, 24 VDC - 1000 W
X12D459										Assembly Power Supply 24 VDC - 1000 W
X750730					3					CTM Wire List
X750621		E				4				Ladder Diagram, Central Alarm
X750622		E				4				Ladder Diagram, System Level Interlock
X750696		D				4				Ladder Diagram, Auxiliary Interlock, System Level Interlock
X750656		D		REF DRAWING						Cabling, Panel A to J-box, CTM Facility
X750655		D		2						Installation and Assembly, LN2 Sensor
X750691		D			3					LN2 Sensor Head
X750629		E		2						Panel "A", Enclosure Data Acquisition Control Center
X750628		E			3					Panel, Terminal Panel "A" Enclosure Data Acquisition Control Center

INDENTURED DRAWING LIST

PROGRAM: PSP
CONFIGURED ITEM: CTM

DRAWING NO.	Rep Dwg	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750627		E			3					Panel, Co-ax Panel "A", Enclosure Data Acquisition Control Center
X750640		D		2						Box, Encoder/Stepper Motor Interface
X750638		D								Assy, Schematic, Detail, Remote Slew Box
X750625		J		2						Assy - Pilot Solenoid Valve Panel
X750624		D			3					Labels, Valve Legend, Pilot Solenoid Valve Panel, Pneumatic Control Subsystem
X750748		E		2						Installation, Gyrotron Magnet Power Supply Stand-CTM
X750605		E			3					Schematic/Wire Diagram, Gyrotron Magnet Power Supply Stand
X750749		D			3					Base Union Post 90
X750647		E			3					Assy - Gyrotron Magnet Power Supply Stand
X750649		E				4				Blank, Front Panels
X750650		E				4				Panel Rear, Hardware Mount
X750662		E				4				Box, Shunt Cover
X750737		D				4				L-Bracket, Inductor, Gyrotron Magnet Power Supply Stand
X750745		D				4				Bracket, Terminal Dual 45
X750746		C				4				Terminal Crimp Modified, 4 Hole
X750747		C				4				Terminal, Crimp One Hole
X750619		E				4				Screens Gyrotron Magnet Power Supply Stand
X750605		E				4				Schematic/Wiring Diagram, Gyrotron Magnet Power Supply Stand
X750742		E				4				Assy-AC Adapter Plate, Gyrotron Manget Power Supply Stand
X750648		E				4				Assembly - Frame Structure Gyrotron Magnet Power Supply Stand

INDENTURED DRAWING LIST

PROGRAM: PSP
CONFIGURED ITEM: CTM

DRAWING NO.	Rep Dwg	Dwg. Size	Order of Assembly 1	2	3	4	5	6	7	TITLE
X750626		E					5			Plate Top, Gyrotron Magnet Power Supply Stand
X750651		E					5			Plate Shelf, Gyrotron Magnet Power Supply Stand
X750739		E					5			Bracket, Tee/End, Gyrotron Magnet Power Supply Stand
X750620		E		2						FC-75 Flow Circuit, Gyrotron Window
X750729		E			3					Platform FC-75
X750731		E			3					FC-75 System, Reservoir/Tank
X750642					3					T Signal Conditioning and Enclosure Layout
X750744		E		2						CEA J-box Component Test Module

Drawings in Sign-off:

X750732	Backplate, Filler Gyrotron Interlock and Control Panel
X750674	Schematic Diagram, Main and Gun Magnet Signal Evaluation
X750619	Screens
X750626	Plate Top
X750647	Assy Gyrotron Magnet Power Supply Stand
X750648	Assy Frame Structure
X750748	Gyro Mag P/S Stand Installation - CTM
X750650	Panel Rear Hardware Mount
X750651	Plate Shelf
X750662	Box Shunt Cover
X750745	Bracket Terminal Dual 45°
X750749	Base Union Post 90°

Drawings Started But Not Completed:

X750622	Ladder Diagram, System Level Interlock - CTM
X750696	Ladder Diagram, System Level Auxiliary Interlocks - CTM
X750621	Ladder Diagram, Central Alarm Subsystem - CTM
X750730	CTM Wire List

Drawings Not Yet Started:

X750639	System Diagram, Probe Position Controller
X750643	System Diagram, Bore Vacuum Controls
X750642	ΔT Signal Conditioning and FC-75 J-Box Layout

Drawings With Outstanding and Unincorporated ECR's or/and Action Items:

X750631	Assembly, Data Acquisition and Control Center, Component Test Module
X750629	Panel "A" Enclosure Data Acquisition Control Center
X750640	Interface Panel, Encoder/Stepper Driver, Probe Position Controller
X750744	CEA Junction Box, Component Test Module
X750620	FC-75 Flow Circuit, Gyrotron Window
X750625	Assembly, Pilot Solenoid Valve Panel, Pneumatic Control Subsystem
X750655	Assembly, LN2 Sensor
X750673	Panel Upper Rear Assembly, Gyrotron Magnet Control and Interlock Panel
X744914	Schematic Bore Vacuum Monitor
X744925	CTM - Schematic Seal Vacuum Controller
X744938	Schematic LN2 Controller
X744937	Terminal Designation Diagram System Level Interlock

X721078	Schematic, Bore Vacuum Controller
X744939	Assembly, Chassis LN2 Controller
X750669	Rear Panel, Lower Gyrotron Magnet Control and Interlocks Panel
X750691	LN2 Sensor Head
X750654	Cyromiser, Modified LN2 Controller
X750670	Chassis, Side Gyrotron Magnet Control and Interlocks Panel
X744933	Terminal Designation Diagram Central Alarm Subsystem - CTM
X750663	Rear Panel Lower, Assembly Gyrotron Manget Control and Interlocks Panel
X750638	Assy, Schematic, Detail Remote Slew Box

APPENDIX G

DISPOSITION OF EQUIPMENT

ISD EQUIPMENT

ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OR MFG.	ACQ.DATE	AX NUMBER
Wordprocessor	S-19859	V. Anderson	277	Anderson	87365	ETF-370	83/04	612671
Smart Printer	S-19860	V. Anderson	277	Anderson	87365	172-1185	83/04	612671
Transcriber	S5-0071	V. Anderson	277	Anderson	87365	BM25A	78/02	451261
Typewriter, IBM	S5-1274	V. Anderson	277	Anderson	87365	IBM III	81/03	532089
Computer, Apple	K-2684	K. Andringa	249	Andringa	84710	COMPUTER LISA	84/04	658558
Printer, Apple	K-2853	K. Andringa	249	Andringa	84710	IMAGE/WRITER	84/08	674178
Hard Disc,Pro-File	K-2854	K. Andringa	249	Andringa	84710	HARD/DISK	84/08	674178
Calculator	S5-0989	K. Andringa	249	Andringa	84710	HP41C	82/08	587660
Computer,DEC	K-2069	P.K.Baumgarten	241	Baumgarten	83113	Rainbow	83/07	634648
Interface	L-27155	P.K.Baumgarten	244	Baumgarten	83113	Transceiver	85/01	695157
Calculator	S5-876	P.K.Baumgarten	244	Baumgarten	83113	TI-59	81/12	553381
Printer	S5-877	P.K.Baumgarten	244	Baumgarten	83113	TI-100C	81/12	553381
Calculator	S5-1859	G. Bridgmon	305-M	Bridgmon	84413	TI-58C	81/01	XXXXXXX
Acoustical Room	B-940	J. W. Congdon	305-M	Congdon	84413	ACCOUS. ROOM	76/09	573298
Grit Blast Unit	D1-4019	J. W. Congdon	305-M	Congdon	84413	GHR-40-SG-U	82/02	570089
Power Supply	D1-4025	J. W. Congdon	305-M	Congdon	84413	PS2000	82/04	567186
Control Console	D1-4026	J. W. Congdon	305-M	Congdon	84413	CP620	82/04	567186
Plasma Gun	D1-4027	J. W. Congdon	305-M	Congdon	84413	PG120-4	82/04	567186
Powder Feeder	D1-4028	J. W. Congdon	305-M	Congdon	84413	RF500-3	82/04	567186
X-Y Traverse	D1-4029	J. W. Congdon	305-M	Congdon	84413	BAY STATES	82/04	567186
Spray Booth	D1-4030	J. W. Congdon	305-M	Congdon	84413	SB-102	82/04	567186
Isomet Saw	D1-4480	J. W. Congdon	305-M	Congdon	83410	ISOMET	82/07	581377
Balance	D1-4488	J. W. Congdon	305-M	Congdon	83410	1602-MP6/VCD	82/09	583118
Balance	D1-4489	J. W. Congdon	305-M	Congdon	83410	1264	82/09	583118
Micrometer	D1-4490	J. W. Congdon	305-M	Congdon	83410	599-246	82/07	582[illegible]
Accoustical Rm	D1-4684	J. W. Congdon	305-M	Congdon	84413	METRO INC	83/05	573368
Air Compressor	D1-4987	J. W. Congdon	305-M	Congdon	84413	SSPUNT	82/12	601043
Cut-off Machine	D1-5912	J. W. Congdon	305-M	Congdon	83410	BL-10-1055 260	83/06	611197
Oven	D1-5913	J. W. Congdon	305-M	Congdon	84413	52201-162	83/06	611179
Plasma Arc	D1-6060	J. W. Congdon	305-M	Congdon	84413	STS-22881	83/04	X6883
Balance	D1-6530	J. W. Congdon	305-M	Congdon	83410	SARTORIUS	84/01	646141
Balance,Mettler	D1-6720	J. W. Congdon	305-M	Congdon	83410	AE160	84/04	663387
Computer	K-2431	J. W. Congdon	305-M	Congdon	83410	IBM PC	83/11	640670
Microscope	L-25469	J. W. Congdon	305-M	Congdon	83410	MICROSCOPE	81/05	537556
Thickness Gauge	L-26447	J. W. Congdon	305-M	Congdon	83410	DIGITAL 780/757	84/02	658451
Micrometer Comparator	L-26519	J. W. Congdon	305-M	Congdon	83410	MICROMETER	84/03	656442
Calculator	S5-1005	J. W. Congdon	305-M	Congdon	83410	TI59	82/12	595681
Printer, TI	S5-1006	J. W. Congdon	305-M	Congdon	83410	PC100C	82/12	595681
Camera,Microscope	S5-1255	J. W. Congdon	305-M	Congdon	83410	MICROSCOPE SK70	81/07	547138
Calculator	S5-1378	J. W. Congdon	305-M	Congdon	83410	TI35	84/02	634809
Calculator	S5-1379	J. W. Congdon	305-M	Congdon	83410	TI35	84/02	634809
Ultrasonic Cleaner	S6-0159	J. W. Congdon	305-M	Congdon	83410	ULTRASONIC	78/09	465028
Calculator	S5-0772	F. E. Driggers	245	Driggers	87351	HP41CB	81/05	541079
Transducer Indicator	B-690	H. W. Randolph	305-M	EED	33005	GAGE TRANS.	76/11	413033
Al. Freeze Pt. Stnd.	B-848	H. W. Randolph	305-M	EED	33005	FREEZ. POINT	81/08	537034
Control Computer	D1-2387	H. W. Randolph	305-M	EED	33005	9845-C,HP	81/06	530230
Leak Detector	D1-2392	H. W. Randolph	305-M	EED	33005	DELTA AD-100	81/03	527524
DC Voltage Source	D1-2393	H. W. Randolph	305-M	EED	33005	FLUKE 343A	81/03	529938
Power Supply	D1-2394	H. W. Randolph	305-M	EED	33005	FLUKE 415B	81/03	529938
Electrometer	D1-2398	H. W. Randolph	305-M	EED	33005	610C	81/03	529955

ISD EQUIPMENT

ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OR MFG.	ACQ.DATE	AS NUMBER
Picoammeter	D1-2399	H. W. Randolph	305-M	EED	33005	616	81/03	529955
Bath,Constant Temp.	D1-2400	H. W. Randolph	305-M	EED	33005	C126800	81/03	529959
Lab. Controller	D1-2401	H. W. Randolph	305-M	EED	33005	RTP 7431/30	81/06	530280
Multimeter	D1-2403	H. W. Randolph	305-M	EED	33005	3456A	81/04	529956
Roughing Pump	D1-2426	H. W. Randolph	305-M	EED	33005	DOE/EXCESS	81/03	530683
Vacuum System	D1-2503	H. W. Randolph	305-M	EED	33005	FC-1800	81/04	534761
Power Supply	D1-2504	H. W. Randolph	305-M	EED	33005	CV-8	81/04	534752
Floppy Disc Drive	D1-2589	H. W. Randolph	305-M	EED	33005	9895A	81/06	540562
Cylinder, LN2	D1-2646	H. W. Randolph	305-M	EED	33005	LS-160	81/08	541273
Vacuum Controller	D1-2718	H. W. Randolph	305-M	EED	33005	260	81/08	546403
Drive, Disc	D1-2723	H. W. Randolph	305-M	EED	33005	7906M	81/12	549185
Disc Interface	D1-2724	H. W. Randolph	305-M	EED	33005	98041A	81/12	549185
Fast Processor	D1-2725	H. W. Randolph	305-M	EED	33005	98403A	81/12	549185
Vacuum Pump	D1-2818	H. W. Randolph	305-M	EED	33005	WELCH 1397	81/08	546403
Cylinder, LN2	D1-2888	H. W. Randolph	305-M	EED	33005	LS-160	81/08	541273
Tool Chest	D1-3876	H. W. Randolph	305-M	EED	33005	AUG/TOOL	82/02	565876
Valve, Gate	D1-3967	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/06	569120
Valve, Gate	D1-3968	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/06	569120
Valve	D1-3969	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/06	569120
Valve	D1-3970	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/06	569120
Valve	D1-3971	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/05	569120
Valve	D1-3972	H. W. Randolph	305-M	EED	33005	AIRCO 5000	82/05	569120
Valve	D1-3973	H. W. Randolph	305-M	EED	33005	Airco-5100	82/06	569120
10" Gate Valve	D1-3974	H. W. Randolph	305-M	EED	33005	AIRCO 5100	82/06	569120
10" Gate Valve	D1-3975	H. W. Randolph	305-M	EED	33005	AIRCO 5100	82/06	569120
SS Vacuum Chamber	D1-4145	H. W. Randolph	305-M	EED	33005	UNITED TECH.	82/06	573343
Window Module	D1-4150	H. W. Randolph	305-M	EED	33005	BR20	82/04	573368
Oscilloscope	D1-4459	H. W. Randolph	305-M	EED	33005	TEKRON 7104	82/08	575973
Amplifier	D1-4463	H. W. Randolph	305-M	EED	33005	TEKRON 7A-29	82/08	575973
Time Base	D1-4464	H. W. Randolph	305-M	EED	33005	TEKRON 7B-15	82/08	575973
Electron Gun	D1-4465	H. W. Randolph	305-M	EED	33005	STIH-270-2	83/09	607981
Feedthrough	D1-4466	H. W. Randolph	305-M	EED	33005	402-7463-1	83/09	607981
Enclosure, HV	D1-4467	H. W. Randolph	305-M	EED	33005	0503-1563-0	83/09	607981
I/O Expander	D1-4468	H. W. Randolph	305-M	EED	33005	9878A	82/08	583119
Controller	D1-4469	H. W. Randolph	305-M	EED	33005	RTP7431/30	82/09	583140
UTR Plate	D1-4470	H. W. Randolph	305-M	EED	33005	RTP7504/34	82/09	583140
Card, Converter	D1-4471	H. W. Randolph	305-M	EED	33005	RTP7436/21	82/09	583140
Leak Detector	D1-4473	H. W. Randolph	305-M	EED	33005	AD200	82/08	575966
Pyrometer, Ircon	D1-4474	H. W. Randolph	305-M	EED	33005	R35310-0-1	82/09	576001
Gauss Meter	D1-4475	H. W. Randolph	305-M	EED	33005	LDJMOD511	82/09	R08213
Oscilloscope	D1-4476	H. W. Randolph	305-M	EED	33005	TEKRON 475A44	82/08	575974
Camera	D1-4477	H. W. Randolph	305-M	EED	33005	C30-BP	82/08	575974
Ultrasonic Cleaner	D1-4486	H. W. Randolph	305-M	EED	33005	B-42	82/08	581367
Transformer, 75KVA	D1-4496	H. W. Randolph	305-M	EED	33005	WESTINGHOUSE	82/09	586827
Transformer, 75KVA	D1-4497	H. W. Randolph	305-M	EED	33005	WESTINGHOUSE	82/09	586827
Transformer, 75KVA	D1-4498	H. W. Randolph	305-M	EED	33005	WESTINGHOUSE	82/09	586827
Gun, Electron	D1-5965	H. W. Randolph	305-M	EED	33005	STIH-270-2	83/09	607981
Transformer	D1-5966	H. W. Randolph	305-M	EED	33005	62055443-0	83/04	607981
Gun, Electron	D1-6246	H. W. Randolph	305-M	EED	33005	STIH-270-2MC	83/10	615492
Gun, Electron	D1-6247	H. W. Randolph	305-M	EED	33005	STIH-270-2MC	83/10	615492

ESD EQUIPMENT

ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OR MFG.	ACQ.DATE	AX NUMBER
Computer, IBM	D1-6597	H. W. Randolph	251	EED	33005	IBM-A419D	84/03	653970
Leak Detector	D1-6600	H. W. Randolph	305-M	EED	33005	VEECOMS-20	84/04	653570
Leak Detector	D1-6601	H. W. Randolph	305-M	EED	33005	VEECOMS-20	84/04	653570
Recorder, XY	D1-6610	H. W. Randolph	305-M	EED	33005	7045B-001-006	84/03	653597
Recorder, XY	D1-6611	H. W. Randolph	305-M	EED	33005	7045B-001-006	84/03	653597
Generator, Pulse	D1-6612	H. W. Randolph	305-M	EED	33005	HP-8005B	84/03	653597
Counter, Multifunction	D1-6613	H. W. Randolph	305-M	EED	33005	FLUKE 1953A	84/03	653577
Gauss Meter	D1-6615	H. W. Randolph	305-M	EED	33005	BELL 620-R	84/04	653560
Integrator	D1-6616	H. W. Randolph	305-M	EED	33005	EGG-162	84/03	653583
Voltmeter	D1-6618	H. W. Randolph	305-M	EED	33005	HP-3456A	84/04	653559
Voltmeter	D1-6619	H. W. Randolph	305-M	EED	33005	HP-3456A	84/04	653559
Controller, Vac. Gauge	D1-6622	H. W. Randolph	305-M	EED	33005	270-004	84/03	563574
Controller, Vac. Gauge	D1-6623	H. W. Randolph	305-M	EED	33005	270-004	84/03	653574
Function Generator	D1-6624	H. W. Randolph	305-M	EED	33005	WAVETEK 164	84/03	657797
Function Generator	D1-6625	H. W. Randolph	305-M	EED	33005	WAVETEK 164	84/03	657797
Oscilloscope	D1-6626	H. W. Randolph	305-M	EED	33005	2465-300 MHZ	84/03	653569
Camera, Scope	D1-6627	H. W. Randolph	305-M	EED	33005	C30B-01	84/03	653569
Oscilloscope	D1-6628	H. W. Randolph	305-M	EED	33005	HP-1740A	84/03	653558
Oscilloscope	D1-6629	H. W. Randolph	305-M	EED	33005	HP-1740A	84/03	653558
Recorder,Stripchart	D1-6630	H. W. Randolph	305-M	EED	33005	HP-414A	84/03	653557
Amplifier,S.C.	D1-6631	H. W. Randolph	305-M	EED	33005	8802A	84/03	653557
Amplifier,S.C.	D1-6632	H. W. Randolph	305-M	EED	33005	8802A	84/03	653557
Amplifier,S.C.	D1-6633	H. W. Randolph	305-M	EED	33005	8802A	84/03	653557
Amplifier,S.C.	D1-6634	H. W. Randolph	305-M	EED	33005	8802A	84/03	653557
Analyzer,Spectrum	D1-6635	H. W. Randolph	305-M	EED	33005	HP-141T	84/03	653556
Pump, Mech.	D1-6637	H. W. Randolph	305-M	EED	33005	VARIAN SD300	84/04	657544
Voltmeter,HP	D1-6742	H. W. Randolph	305-M	EED	33005	3456A	84/06	655196
Voltmeter,HP	D1-6743	H. W. Randolph	305-M	EED	33005	3456A	84/06	655196
Air Drier	D1-6765	H. W. Randolph	FabLab	EED	33005	HEAT LES-25HA1	84/06	665349
Sander	IT30376	H. W. Randolph	305-M	EED	33005	6080	81/11	560576
Caliper,6"	IT30475	H. W. Randolph	305-M	EED	33005	6"	82/09	580056
Caliper,24"	IT30476	H. W. Randolph	305-M	EED	33005	24"	82/09	580056
Micrometer set	IT30477	H. W. Randolph	305-M	EED	33005	Set	82/09	580056
Depth Gage	IT30478	H. W. Randolph	305-M	EED	33005	Gage	82/09	580056
Cordless Drill	IT30482	H. W. Randolph	305-M	EED	33005	1940	82/06	XXXXXX
Hammer Drill	IT30483	H. W. Randolph	305-M	EED	33005	5077-09	82/06	XXXXXX
Band Saw	IT30484	H. W. Randolph	305-M	EED	33005	3123	82/06	XXXXXX
Drill Motor	IT30485	H. W. Randolph	305-M	EED	33005	1065	82/06	XXXXXX
Saw, Recip.	IT30486	H. W. Randolph	305-M	EED	33005	3105-09	82/06	XXXXXX
Vacion P.S.	L-13234	H. W. Randolph	305-M	EED	33005	VARIAN 9210062	72/12	338745
Baratron Gauge	L-13354	H. W. Randolph	305-M	EED	33005	PRESS/HEAD	72/10	331752
Baratron Control	L-13355	H. W. Randolph	305-M	EED	33005	MKS-170M-7	72/10	331752
Ionizing Control	L-14657	H. W. Randolph	305-M	EED	33005	Itek	77/02	100187
Programmer,Mass	L-14658	H. W. Randolph	305-M	EED	33005	NUC-LAB 091-6	77/02	100187
Scope Display	L-14659	H. W. Randolph	305-M	EED	33005	NUC-LAB 280-1	77/02	100187
Spectrometer,Mass	L-14660	H. W. Randolph	305-M	EED	33005	NUC-LAB 270-5	77/02	100187
Pyrometer,Optical	L-17649	H. W. Randolph	305-M	EED	33005	OPTICAL REDEYE	82/09	584869
Tool Microscope	L-20523	H. W. Randolph	305-M	EED	33005	MICROMETER	66/08	183446
Calculator	SS-0990	H. W. Randolph	251	EED	33005	HP21	78/02	456667
Camera, Land	SS-1002	H. W. Randolph	251	EED	33005	SX70	82/10	591457

LSD EQUIPMENT

ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OF MFG.	ACQ.DATE	A) NUMBER
Projector	S5-1404	H. W. Randolph	251	EED	33005	3M J4-413	84/03	694142
Diffusion Pump&Baffle	U-9590	H. W. Randolph	FabLab	EED	33005	DIFF. PUMP	81/07	543763
Diffusion Pump&Baffle	U-9591	H. W. Randolph	305-M	EED	33005	DIFF. PUMP	81/07	543763
Cylinder,LN2	Z-1551	H. W. Randolph	305-M	EED	33005	LS-160	81/07	541147
Cylinder,LN2	Z-1552	H. W. Randolph	305-M	EED	33005	LS-160	81/07	541147
Computer,FET	E-1282	A. S. Ferrara	253	Ferrara	83420	COMPUTER COMM	81/05	540452
Disk Drive, FET	E-1283	A. S. Ferrara	253	Ferrara	83420	DISK DRIVE	81/05	540452
Printer, FET	E-1284	A. S. Ferrara	253	Ferrara	83420	PRINTER	81/05	540452
Calculator	S5-0866	A. S. Ferrara	253	Ferrara	83420	HP340	81/11	561030
Monitor, 10CH.	D1-6690	J. R. Taylor	248	Hendrix	83113	08486	84/05	668240
Monitor, 10CH.	D1-6690	J. R. Taylor	248	Hendrix	83113	Q-8486	84/05	668248
Terminal, Display	D1-6338	D. W. Howard	243	Howard	83420	3279 S3G	83/11	626565
Calculator	S5-0128	D. W. Howard	243	Howard	83420	TEX INS.	78/11	472493
Printer, TI	S5-0719	D. W. Howard	243	Howard	83420	PLOTTER PC-100C	81/02	535215
Calculator	S5-0875	D. W. Howard	243	Howard	83420	TEX INS. TI59	81/12	N08583
LN2 Piping		LSD	773-A	LSD	00000	CVI	84/10	664138
Substation,2500 KVA		LSD	773-A	LSD	00000	GE	84/10	651047
Control Room Floor		LSD	773-A	LSD	00000	Vendor Fab.	84/09	664159
Water Treatment Sys.	AM04643	LSD	773-A	LSD		Nalco	85/02	C85562
Cooling Tower Strainer	AM04643	LSD	773-A	LSD		Zurn	85/02	XXXXXXX
Cooling Tower Pump	AM04643	LSD	773-A	LSD		Goulds	85/02	C85170
Cooling Tower Pump	AM04643	LSD	773-A	LSD		Goulds	85/02	C85170
Recorder	D1-6224	P. Makohon	773-A	LSD			83/11	623167
Cooling Tower	D1-6670	LSD	773-A	LSD	00000	CCTC PL-216-3A	84/05	657626
Power Supply Bldg.	D1-6676	LSD	773-A	LSD	00000	773-50A	84/05	664139
Transformer	D1-6744	LSD	773-A	LSD	LSD	480-208/120	84/06	665171
Transformer	D1-6745	LSD	773-A	LSD	LSD	480-208/120	84/06	665171
Control Center,MCC	D1-6898	LSD	773-A	LSD	00000	NEMA 12,65000	84/05	535201
Calculator	S5-0707	P. A. Makohon	246	Makohon	33001	1150	81/05	541941
Vacuum Cleaner	S5-1509	G. H. Nelson	Fablab	Nelson	83420	VACUUM 5455	84/06	671857
Airbrasive Unit	B-849	H. W. Randolph	305-M	OPEN		AIRBRASIVE	81/08	537034
Glove Box	B-865	H. W. Randolph	305-M	OPEN		GLOVEBOX	72/04	530721
Balance	D1-2700	R. H. Young	F-055	OPEN		1205MP	81/08	549026
Power Supply	D1-2713	H. W. Randolph	305-M	OPEN		CV-100	82/01	548378
Sedigraph	D1-2770	J. W. Congdon	305-M	OPEN		5000D	82/01	556967
Compressor	D1-2777	R. H. Young	F-055	OPEN		TE-22TS-RF	81/10	548422
Integrator	D1-2785	R. H. Young	F-055	OPEN		162	81/09	548414
Integrator	D1-2786	R. H. Young	F-055	OPEN		165	81/09	548414
Pump	D1-2801	R. H. Young	F-055	OPEN		L-26879	81/11	548144
System,Spectrometry	D1-2802	H. W. Randolph	305-M	OPEN		L-26880	81/11	548456
Integrator	D1-2886	R. H. Young	F-055	OPEN		165	81/09	548414
Illuminator Sys.	D1-2890	R. H. Young	F-055	OPEN		S-1000A	82/03	570285
Cabinet, 24'	D1-3086	R. H. Young	F-055	OPEN		63-0088	81/12	559929
Pore Sizer	D1-4481	J. W. Congdon	305-M	OPEN		9300	82/09	576092
Instrument Beam	D1-4614	R. H. Young	F-055	OPEN		675	82/09	580631
Frame,Liner Support	D1-6865	J. W. Congdon	305-M	OPEN		TSD-212,213	84/11	677241
Counter	L-24179	R. H. Young	F-055	OPEN		1205280A	75/03	378223
Oscilloscope	T-22116	R. H. Young	F-055	OPEN		TEXTRONIC	73/08	C42188
Furnace	U-7690	R. Young	F-057	Overcash	85171	Unifab	68/09	C25562
Printer, Apple	E-2852	K. Andringa	249	Plodinec	87366	IMAGE/WRITER	84/08	674178

ISD EQUIPMENT

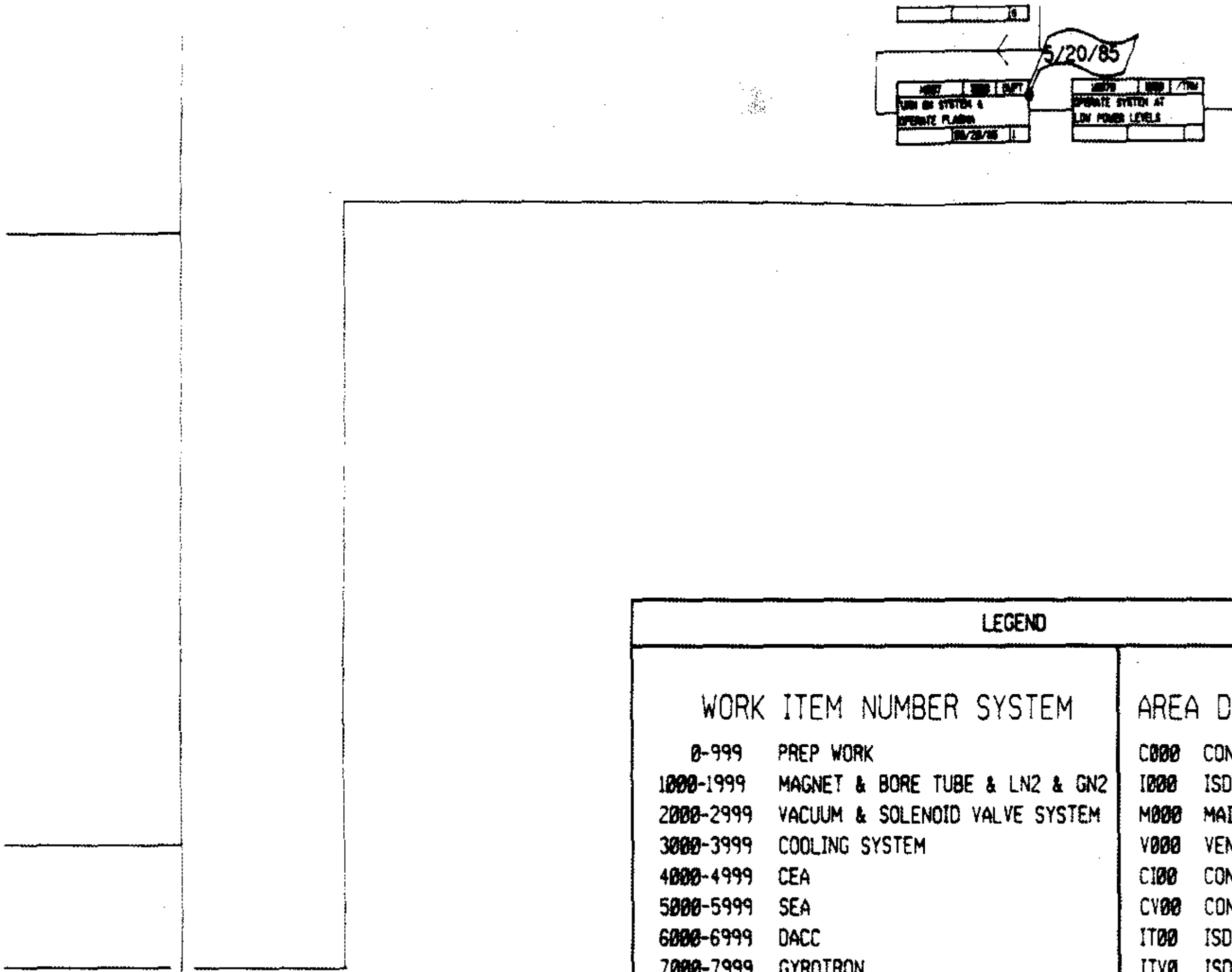
ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OF MFG.	ACQ.DATE	AX NUMBER
Balance	D1-5914	J. W. Congdon	305-M	STOLEN	84413	26 HMP	83/09	611234
Calculator	S5-0553	P. E. Smith	254	Smith	84710	HEW PAC-33C	80/01	500971
Surface Bench	D1-6306	J. W. Congdon	305-M	Stewart	84420	E74025	83/11	623025
Gyrotron CollectorMagnet		H. W. Randolph	FabLab	TRW	00000	Varian	84/08	TRW Acq.
Argon Inj. Control		H. W. Randolph	FabLab	TRW	00000	TRW Fab.	84/10	TRW Acq.
Power Sampler		H. W. Randolph	FabLab	TRW	00000	Varian	84/12	TRW Acq.
Spare Parts,90 KV		H. W. Randolph	FabLab	TRW	00000	UVC	84/12	675197
Gyrotron Gun Magnet		H. W. Randolph	FabLab	TRW	00000	Varian	84/09	TRW Acq.
Vac. Chamber Stand		H. W. Randolph	FabLab	TRW	00000	TRW Fab.	84/07	TRW Acq.
Power Supply		H. W. Randolph	FabLab	TRW	00000	UVC-90KV	84/10	TRW Acq.
Spare Parts,4 KV		H. W. Randolph	FabLab	TRW	00000	UVC	84/12	675193
Control Room Cabinets		H. W. Randolph	FabLab	TRW	00000	Optima	84/09	TRW Acq.
DC Block		H. W. Randolph	FabLab	TRW	00000	Varian	84/09	TRW Acq.
Magnet Stand		H. W. Randolph	FabLab	TRW	00000	TRW Fab.	84/06	TRW Acq.
Bore Tube Stand		H. W. Randolph	FabLab	TRW	00000	TRW Fab.	84/07	TRW Acq.
Gyrotron Power Supplies		H. W. Randolph	FabLab	TRW	00000	Varian	84/11	TRW Acq.
Mode Filter		H. W. Randolph	FabLab	TRW	00000	Varian	84/09	TRW Acq.
Magnet		H. W. Randolph	FabLab	TRW	00000	WRI-9683	84/06	TRW Acq.
High P. Heat Exchanger	AM04643	LSD	773-A	TRW	00000	Mueller	85/02	C85169
Low Press. DI. Pump	AM04643	LSD	773-A	TRW	00000	Goulds	85/02	C85170
Low P. Heat Exchanger	AM04643	LSD	773-A	TRW	00000	Mueller	85/02	C85169
High press. DI. Pump	AM04643	LSD	773-A	TRW	00000	Goulds	85/02	C85170
DI.Water Tank	AM04643	LSD	773-A	TRW	00000	Midland Steel	85/02	C85172
Gate Valve,24"	D1-6598	H. W. Randolph	305-M	TRW	00000	SXB-242	84/04	648198
Gate Valve,24"	D1-6599	H. W. Randolph	305-M	TRW	00000	SXB-242	84/04	648198
Vacuum Pump	D1-6602	H. W. Randolph	305-M	TRW	00000	1736	84/04	657517
Vacuum Pump	D1-6603	H. W. Randolph	305-M	TRW	00000	1736	84/04	657517
LN2 Cold Trap	D1-6604	H. W. Randolph	305-M	TRW	00000	LNB 242	84/03	648180
LN2 Cold Trap	D1-6605	H. W. Randolph	305-M	TRW	00000	LNB 242	84/03	648180
20" Diffusion Pumps	D1-6606	H. W. Randolph	305-M	TRW	00000	Varian,DIFF 20	84/10	648183
20" Diffusion Pumps	D1-6607	H. W. Randolph	305-M	TRW	00000	Varian,DIFF-20	84 10	648183
Vacuum Pump	D1-6608	H. W. Randolph	305-M	TRW	00000	1395-M-01	84/03	654063
Vacuum Pump	D1-6609	H. W. Randolph	305-M	TRW	00000	1395-M-01	84/03	654063
Power Meter	D1-6614	H. W. Randolph	305-M	TRW	00000	HP-432B	84/03	655560
Water Load	D1-6617	H. W. Randolph	305-M	TRW	00000	VLA-8000	84/04	653601
Radiation Meter	D1-6620	H. W. Randolph	305-M	TRW	00000	Narda, 8616	84/03	653567
Controller, Vac. Gauge	D1-6621	H. W. Randolph	305-M	TRW	00000	270-004	84/03	653574
Helium Vent Line	D1-6692	H. W. Randolph	305-M	TRW	00000	CTM	84/05	648110
Helium Transfer Line	L-26959	H. W. Randolph	FabLab	TRW	00000	HELIUM TRANS	84/10	679400
Helium Transfer Line	L-26960	H. W. Randolph	FabLab	TRW	00000	HELIUM TRANS	84/10	679400
Helium Transfer Line	L-26961	H. W. Randolph	FabLab	TRW	00000	HELIUM TRANS	84/10	679400
Calculator	S5-0220	S. V. Topp	227	Topp	82412	HEW PAC-21	77/04	5-19275
Module 10 Channel	D1-2461	R. H. Young	F-055	Young	84710	MC110	81/04	530049
Leak Detector,Spect.	D1-2637	R. H. Young	F-055	Young	84710	F7570-302	81/08	540250
Balance	D1-2701	R. H. Young	F-055	Young	84710	1.305MP	81/08	549026
Monochromator	D1-2702	R. H. Young	F-055	Young	84710	HR-320	81/10	540784
System, Microscan	D1-2703	R. H. Young	F-055	Young	84710	F30435671	81/10	540384
Recorder	D1-2769	R. H. Young	F-055	Young	84710	7132A	81/09	540395
GE Detector	D1-2779	R. H. Young	F-055	Young	84710	IGP 205240	81/09	540412
Oscilloscope	D1-2780	R. H. Young	F-055	Young	84710	7834	81/09	540495

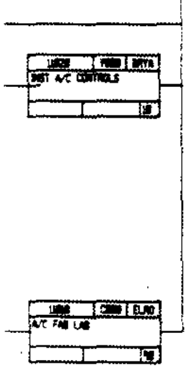
ISD EQUIPMENT

ITEM	TAG NO.	PERSON RESP.	LOCATION	TRANSFER TO:	CUSTODIAN	MODEL OR MFG.	ACQ.DATE	AX NUMBER
Time Base	D1 2781	R. H. Young	F 055	Young	84710	7B80	81/09	548495
Time Base	D1-2782	R. H. Young	F-055	Young	84710	7B85	81/09	548495
Amplifier	D1-2783	R. H. Young	F 055	Young	84710	7A24	81/10	548495
Amplifier	D1-2784	R. H. Young	F-055	Young	84710	7A19	81/10	548495
Preamplifier	D1-2787	R. H. Young	F-055	Young	84710	115	81/09	548414
Computer	D1-2826	R. H. Young	F-055	Young	84710	9845T HEW/PAC	81/10	549234
Amplifier	D1-2874	R. H. Young	F 055	Young	84710	7A19	81/10	548495
Table Top	D1-3894	R. H. Young	F-055	Young	84710	RS-510-8	82/03	562481
Dye Laser	D1-4232	R. H. Young	F-055	Young	84710	NDYAG	83/05	575960
Readout, Diode	D1-4261	R. H. Young	F-055	Young	84710	DIODE 7072	82/06	579923
Module, 10 Channel	D1-4384	R. H. Young	F-055	Young	84710	MC1-10	83/06	575870
Multimeter	D1-4434	R. H. Young	F-055	Young	84710	3478A	82/08	579849
Power Supply	D1-4627	R. H. Young	F-055	Young	84710	PDR-5B-VCD	82/10	576121
Fiberscope	L-23891	R. H. Young	F-055	Young	84710	AMR-FS42	73/07	348987
Multimeter	L-26706	R. H. Young	F-055	Young	84710	3438A	84/07	663852
Calculator	S5-0845	R. H. Young	281	Young	84710	HP34C	81/10	555647

APPENDIX H

CTM SCHEDULE





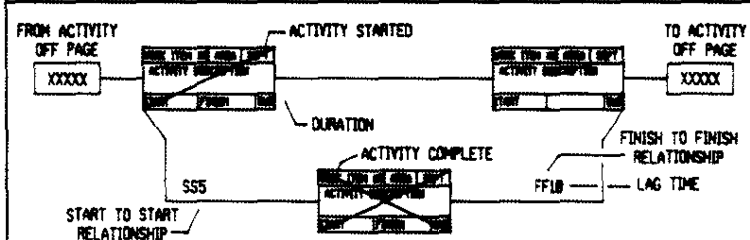
LEGEND

WORK ITEM NUMBER SYSTEM

0-999	PREP WORK
1000-1999	MAGNET & BORE TUBE & LN2 & GN2
2000-2999	VACUUM & SOLENOID VALVE SYSTEM
3000-3999	COOLING SYSTEM
4000-4999	CEA
5000-5999	SEA
6000-6999	DACC
7000-7999	GYROTRON
8000-8999	4KV POWER SUPPLY
9000-9999	90KV POWER SUPPLY
10000-10999	OPERATING & MISC SYSTEMS
11000-11999	AIR CONDITIONING SYSTEM

AREA DESCRIPTION

C000	CONSTRUCTION
I000	ISD
M000	MAINTENANCE
V000	VENDOR
CI00	CONSTR/ISD
CV00	CONSTR/VENDOR
IT00	ISD/TRW
ITV0	ISD/TRW/VENDOR



REVISION NO.	REVISED BY	DATE	REMARKS
2	TJV	11/20/84	STATUS AS OF 11/12/84

PRECEDENCE DIAGRAM

DUPONT-SAVANNAH RIVER LABORATORY

CRS SIRRINE JOB NO. R02075

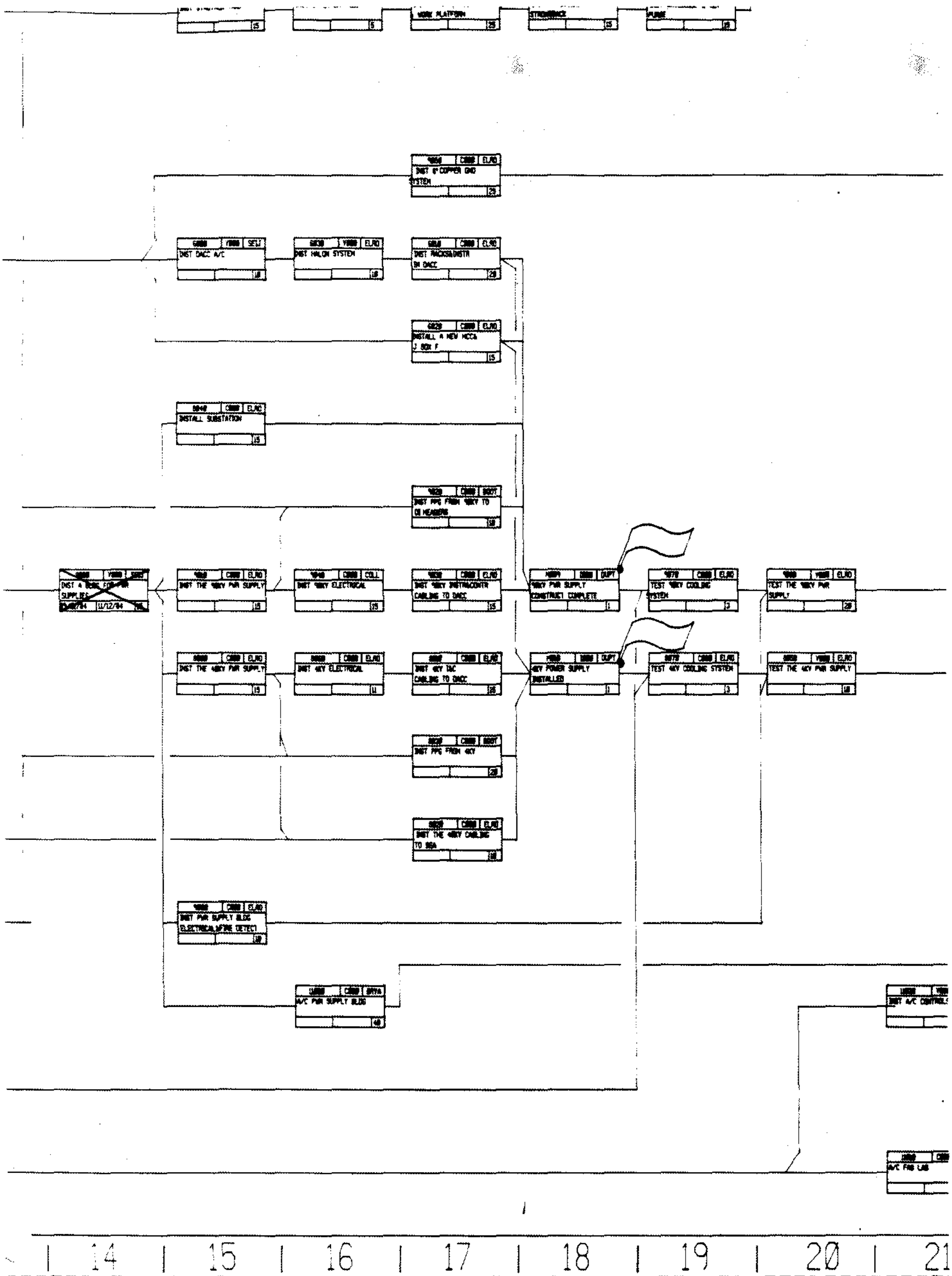
SIRRINE ENGINEERS • ARCHITECTS • PLANNERS

RESEARCH TRIANGLE PARK, NORTH CAROLINA

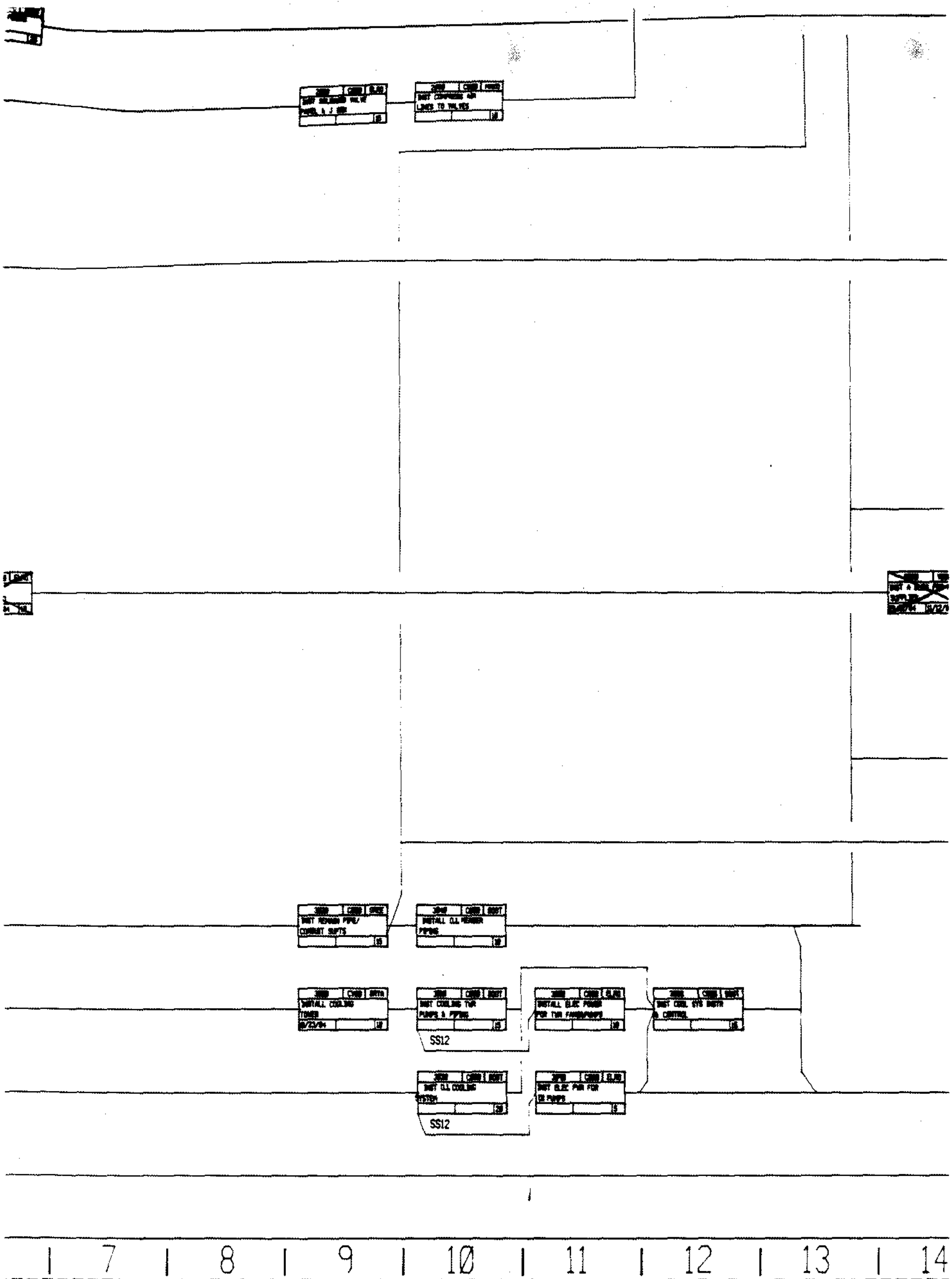
DSN. BY	CKD. BY	APPR. BY	SCALE	DATE	FILE NO.	DRAWING NUMBER
TJV						207500002.JP

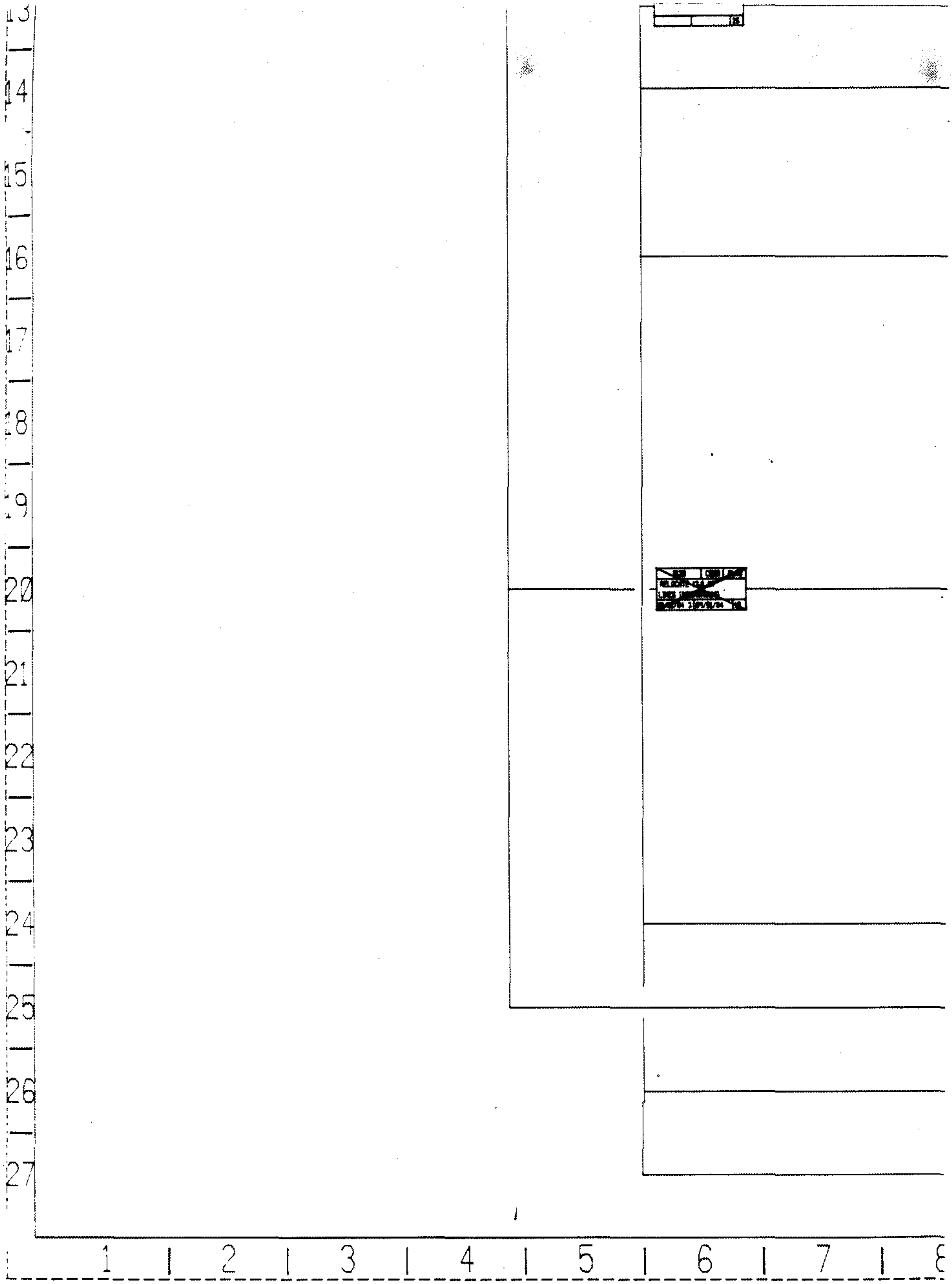
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |

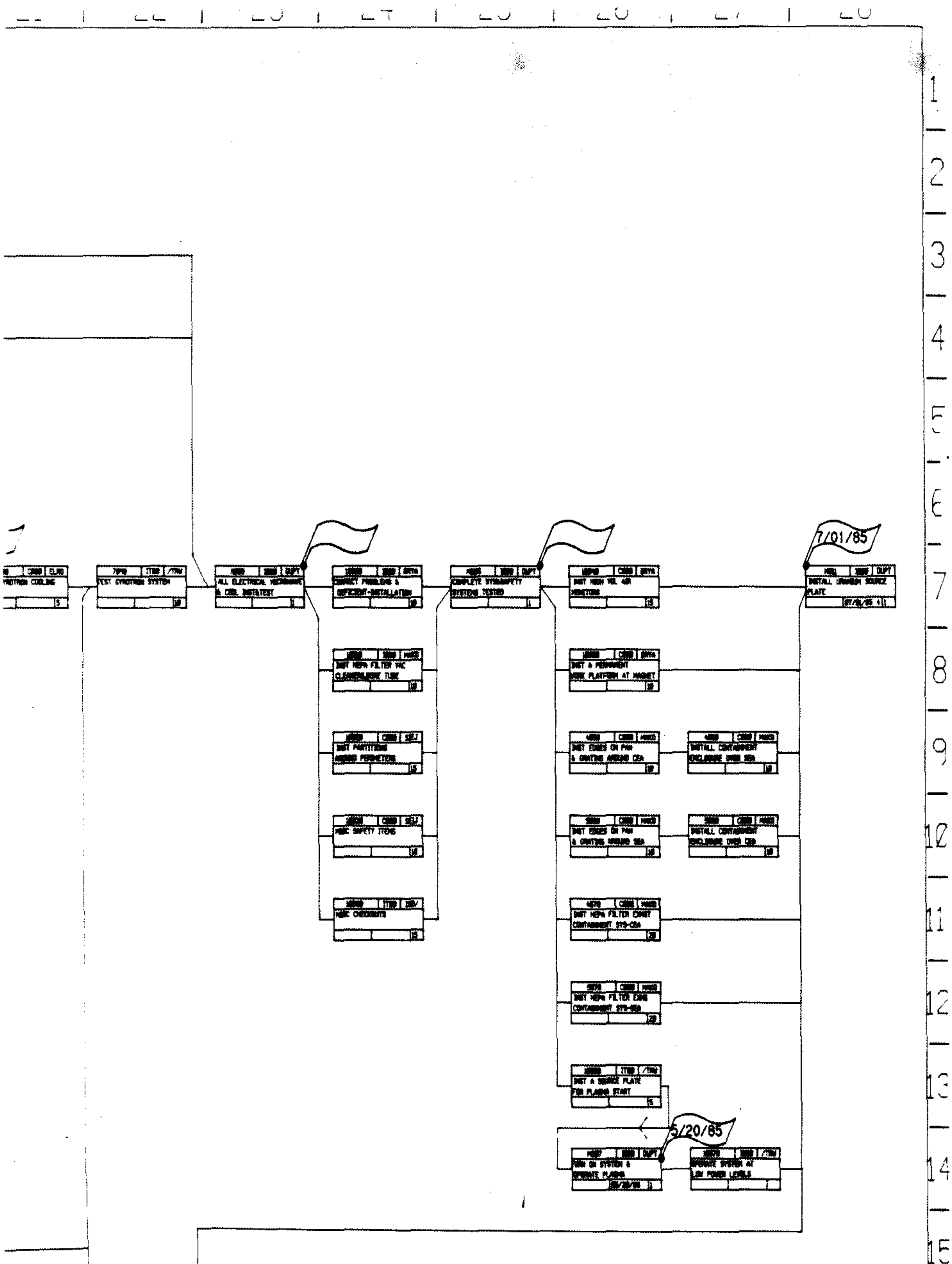
2055REF01.JP

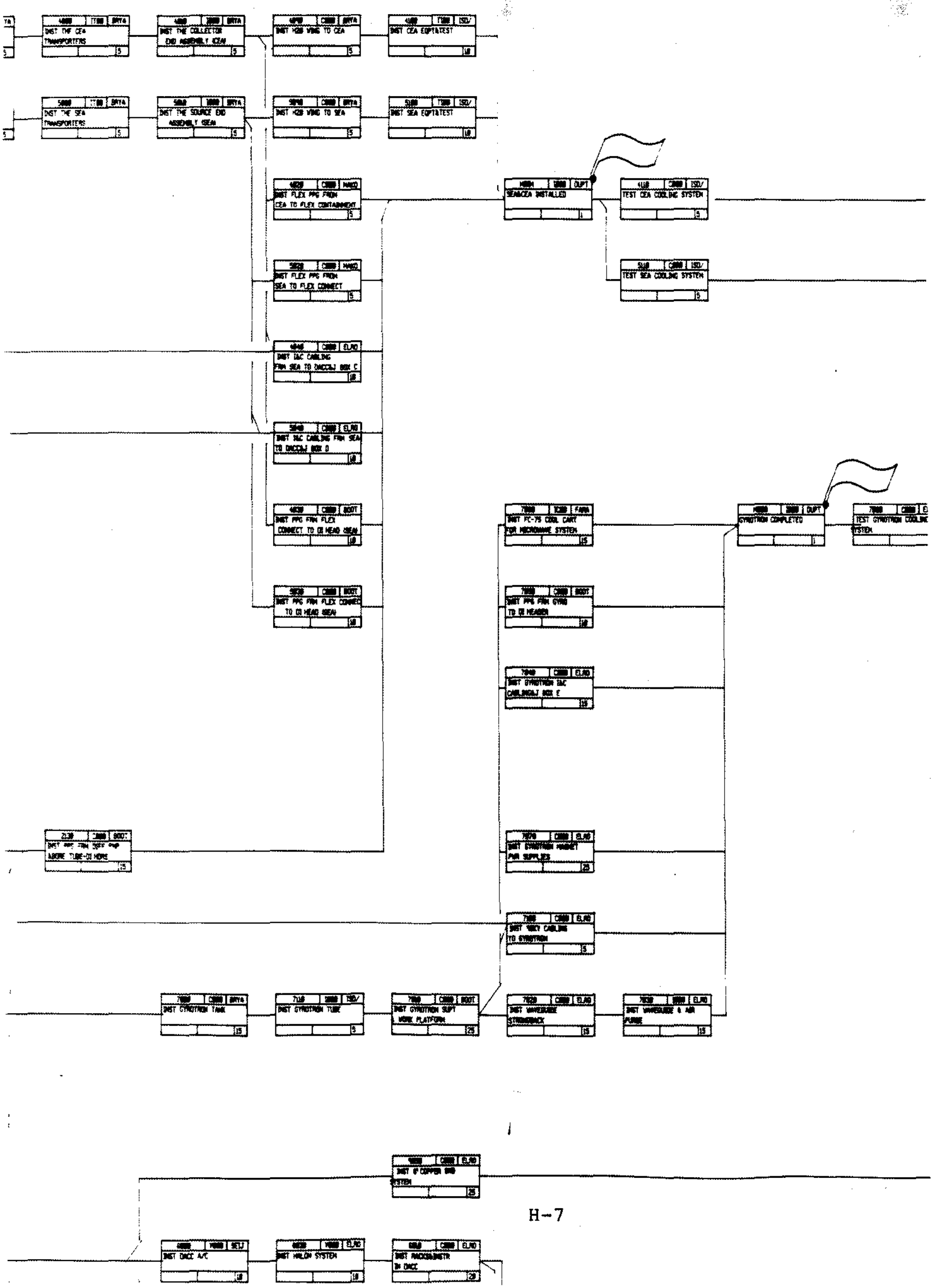


INST HALON SYSTEM
INSTALL SUBSTATION
TEST 4KV COOLING SYSTEM
TEST THE 4KV PWR SUPPLY
A/C PWR SUPPLY BLDG
A/C FAB LAB
14
15
16
17
18
19
20
21

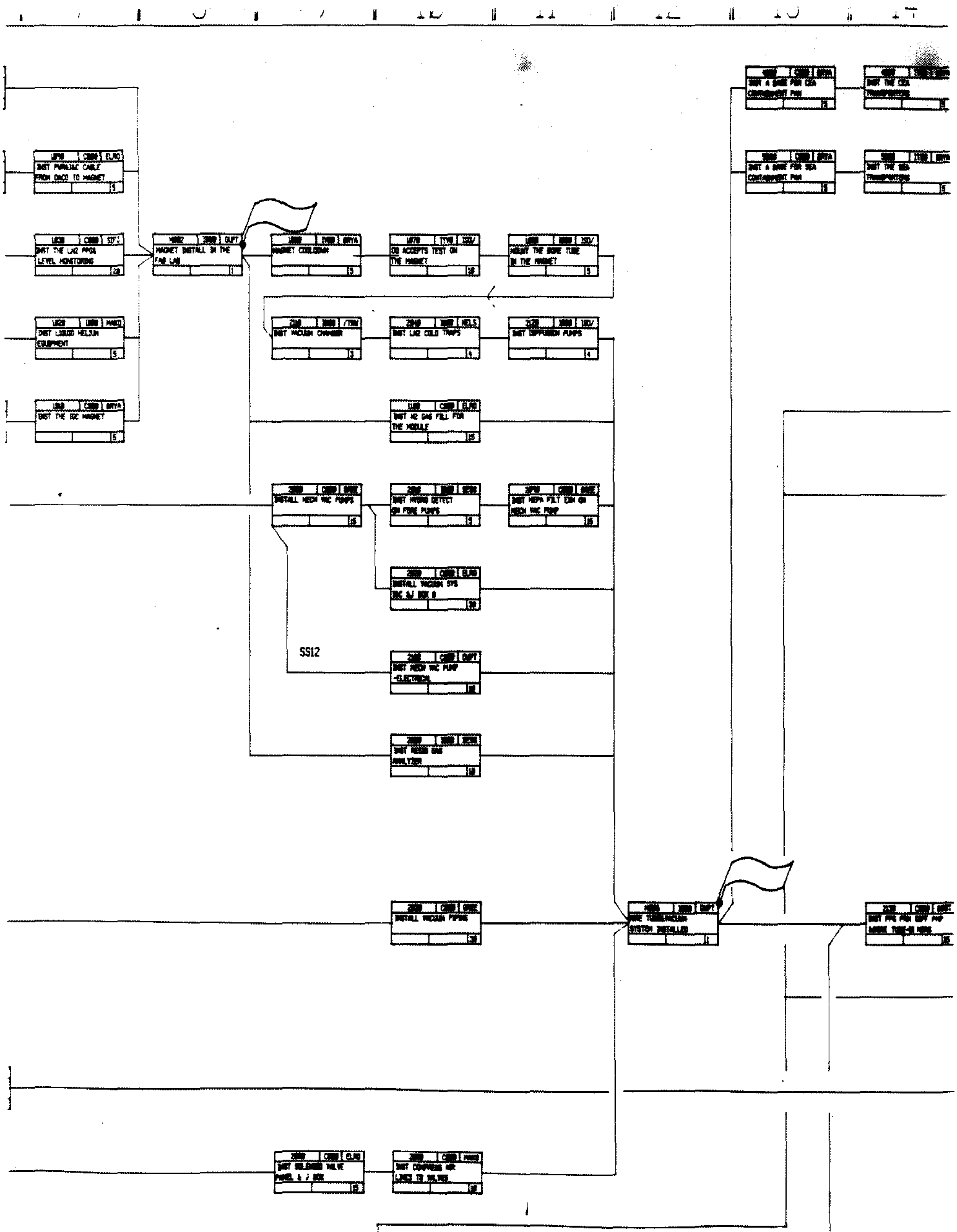

LINES TO VALVES
INSTALL COOLING
TOWER
INSTALL ELEC POWER
& CONTROL
SS12
SS12
7
8
9
10
11
12
13
14

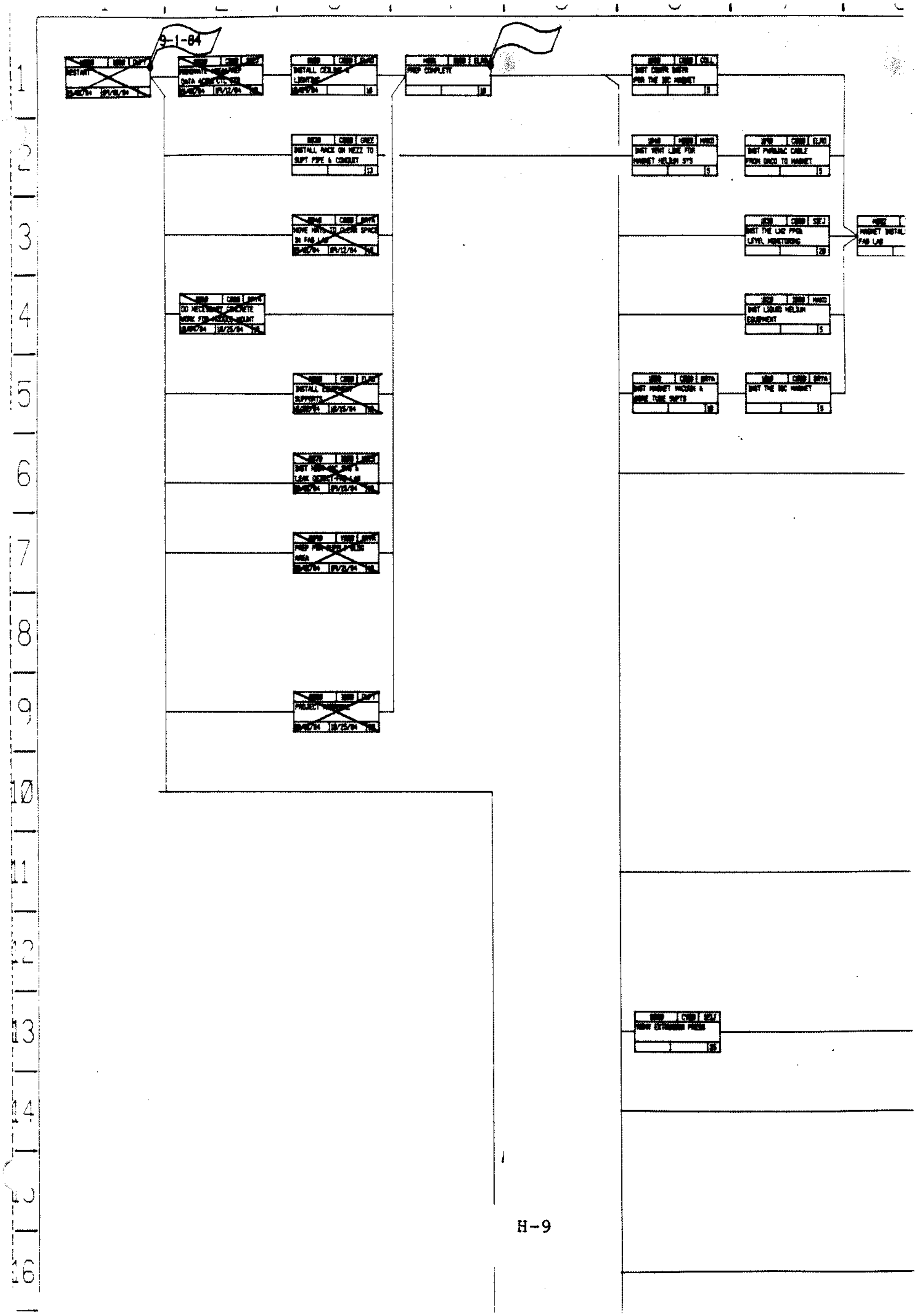



TEST GYROTRON SYSTEM
ALL ELECTRICAL MECHANICAL & COOL INST&TEST
MISC SAFETY ITEMS
MISC CHECKOUTS
7/01/85
INSTALL URANIUM SOURCE PLATE
5/20/85
OPERATE SYSTEM AT LOW POWER LEVELS



INST THE CEA TRANSPORTERS
INST THE COLLECTOR END ASSEMBLY (CEA)
INST H2O VING TO CEA
INST CEA EQPT&TEST
INST THE SEA TRANSPORTERS
INST THE SOURCE END ASSEMBLY (SEA)
INST H2O VING TO SEA
INST SEA EQPT&TEST
INST FLEX PPG FROM CEA TO FLEX CONTAINMENT
SEA&CEA INSTALLED
TEST CEA COOLING SYSTEM
INST FLEX PPG FROM SEA TO FLEX CONNECT
TEST SEA COOLING SYSTEM
INST I&C CABLING FRM SEA TO DACC&J BOX C
INST I&C CABLING FRM SEA TO DACC&J BOX D
INST PPG FRM FLEX CONNECT TO DI HEAD (SEA)
INST PPG FRM FLEX CONNEC TO DI HEAD (SEA)
INST FC-75 COOL CART FOR MICROWAVE SYSTEM
GYROTRON COMPLETED
TEST GYROTRON COOLING SYSTEM
INST PPG FRM GYRO TO DI HEADER
INST GYROTRON I&C CABLING&J BOX E
INST GYROTRON MAGNET PWR SUPPLIES
INST GYROTRON TANK
INST GYROTRON TUBE
INST GYROTRON SUPT & WORK PLATFORM
INST WAVEGUIDE STRONGBACK
INST WAVEGUIDE & AIR PURGE
INST RF COPPER GND SYSTEM
INST DACC A/C
INST HALON SYSTEM
INST RACKS&INSTR IN DACC


INST THE SDC MAGNET
INST LIQUID HELIUM EQUIPMENT
MAGNET INSTALL IN THE FAB LAB
MAGNET COOLDOWN
INST VACUUM CHAMBER
INST LN2 COLD TRAPS
INST DIFFUSION PUMPS
INST N2 GAS FILL FOR THE MODULE
INSTALL MECH VAC PUMPS
INSTALL VACUUM PIPING
SS12


9-1-84
PREP COMPLETE
INSTALL RACK ON MEZZ TO
SUPT PIPE & CONDUIT
FAB LAB

APPENDIX I

RECEIVING OF DEPLETED URANIUM

TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

CC: R. L. Busbee, SRP
E. C. Randall
W. E. Jule, SRL
H. F. Sturm -
B. F. Fowler
W. S. Jones -
E. W. Peeler
T. A. Willis -
H. P. Gibson
C. E. Whitney -
E. Stephens
K. A. Overcash
J. W. Swain -
J. A. Lown
R. E. Pevey
G. Bridgmon
R. H. Young

December 7, 1984

M E M O R A N D U M

TO: K. ANDRINGA

FROM: P. K. SMITH

RECEIVING DEPLETED URANIUM

Attached are the present procedures and arrangements to receive depleted uranium plates and samples for the ISD programs. ISD is beginning to receive depleted uranium on a regular basis from Oak Ridge and occasionally from Rocky Flats and TRW Corp. This is an accountable radioactive material.

We have experienced some procedural problems in earlier shipments in both the supplier-SRP and SRP-SRL transfers. In one instance, Oak Ridge shipped without notifying the receiver, without 741 accountability papers and without previously requesting SRP for an MPM number authorizing and notifying SRP of the impending shipment. In the latest shipment, Oak Ridge did not request an MPM number before shipment or notify the receiver. R. L. Busbee of SRP accountability has called Oak Ridge to insist future shipments are set up with an assigned MPM number.

The transfer to SRL from SRP has an administrative and a procedural problem. SRL accountability procedures presently require accountability of DU to the nearest gram, reportable to a tenth gram, and require the percent U-235 even if less than 0.2%. These data are not available from the suppliers. SRP, OR, and RF accountability is to the nearest kilogram, reported to a tenth kilogram and the U-235 content is required to be less than 0.2%. A letter from the SRL Accountability Review Committee (R. E. Pevey) is circulating to SRL management for approval to bring SRL accountability into coincidence with that of SRP. Meanwhile, functional but inaccurate weights to 0.1 g are determined by measuring thicknesses of Cu and DU in the laminated plates to get volume percent DU, then calculating the weight of DU from the total weight of the plate using the metal densities and volume percent DU. Weight % U-235 is taken to be 0.2%.

The procedural problem is that SRL has not had sufficient time to prepare to receive delivery before SRP Receiving needs to transfer. Because of the commercial shipping practices, shipments arrive on Fridays, usually late Friday. According to their procedures, SRP Receiving cannot keep a radioactive shipment more than two days without arranging for locked storage and monitoring by Security. Hence, SRP needs to deliver promptly when arrivals occur on Friday. SRL cannot receive the shipment without first having IDTR accountability papers from SRP. Obtaining Accountability papers and IDTR's is the most time limiting, and these papers cannot be arranged before the shipment arrives. SRL must also coordinate the receiver, the custodian, the use of a loading dock, access to locked storage, physical transfer, OHP notification and accountability, all on short notice.

This procedural problem is being relieved in two ways. R. L. Busbee will tell OR (and other shippers) that SRP will not accept delivery on Fridays. Once in a while, then, Receiving may be asked to hold a shipment overnight until SRL can complete preparations. The SRL Nuclear Materials Control Group will handle each transfer on a case-by-case basis, recognizing that transfer papers may sometimes have to be completed on Monday for a late Friday delivery, although this would be a technical violation of DOE requirements.

PKS:vwa
Atts.

ISD PROCEDURES

<u>SRP</u>	Upon arrival, SRP Receiving (T. L. Folk, 51209) calls addressee (G. Bridgmon, 53687/K. Andringa 55314). If not available, Receiving calls E. W. Peeler (51291) of the SRL Nuclear Materials Control Group.
<u>SRL</u>	Gean Bridgmon (or Eleanor Peeler with help from ISD) makes the following arrangements for SRL to receive the delivery from 713-A.
IDTR/ Accountability	a. Obtain IDTR papers from R. L. Busbee (55036), sign as custodian (R. H. Young (55304) is ISD backup custodian), and deliver IDTR to Eleanor Peeler.
Loading Dock	b. Call C. E. Whitney (53615), or E. Stephens (53656) HLC Supervisors, to arrange a time to receive package at the E-Wing (HLC) loading dock. K. A. Overcash (53035) is a backup for delivery at the F-Wing loading dock.
Moving the Shipment in SRL	c. Arrange to have the package moved immediately from the loading dock to locked up storage (F-055). Two ISD people and a hand truck are required.
Radiation Control	d. Notify J. A. Lown (52909) of OHP that the package is coming and requires monitoring by Radiation Control.
Notify SRP Receiving	e. Tell Tommy Folk (51209) in 713-A when and where to deliver.
Delivery to SRL	f. Upon arrival at SRL, confirm the labels on the package (contents, shipper, addressee, SRP Radiation Control tag). Sign a delivery receipt for the driver.
RC Monitoring	g. Have the package smeared, probed and tagged by a Radiation Control inspector.
Locked Storage	h. Move the package into locked storage (presently F-055).

DISTRIBUTION:

R. T. PROFANT, USDOE-ONMP
J. W. DICKEY, USDOE-SRO
R. M. WEBB, TRW (2)
S. E. SRODULSKI, TRW
E. J. LUKOSIUS, SRP
H. W. RANDOLPH
J. T. LOWE, SRL
J. D. SPENCER
W. E. JULE
K. ANDRINGA
T. R. SLOAN
W. S. JONES
K. BRYAN
H. E. HOOTMAN
P. K. SMITH
A. S. FERRARA
J. W. CONGDON
F. E. DRIGGERS
SRL RECORDS (4)