ORNL/Sub/81-21099/1&08

26 FEBRUARY 1982

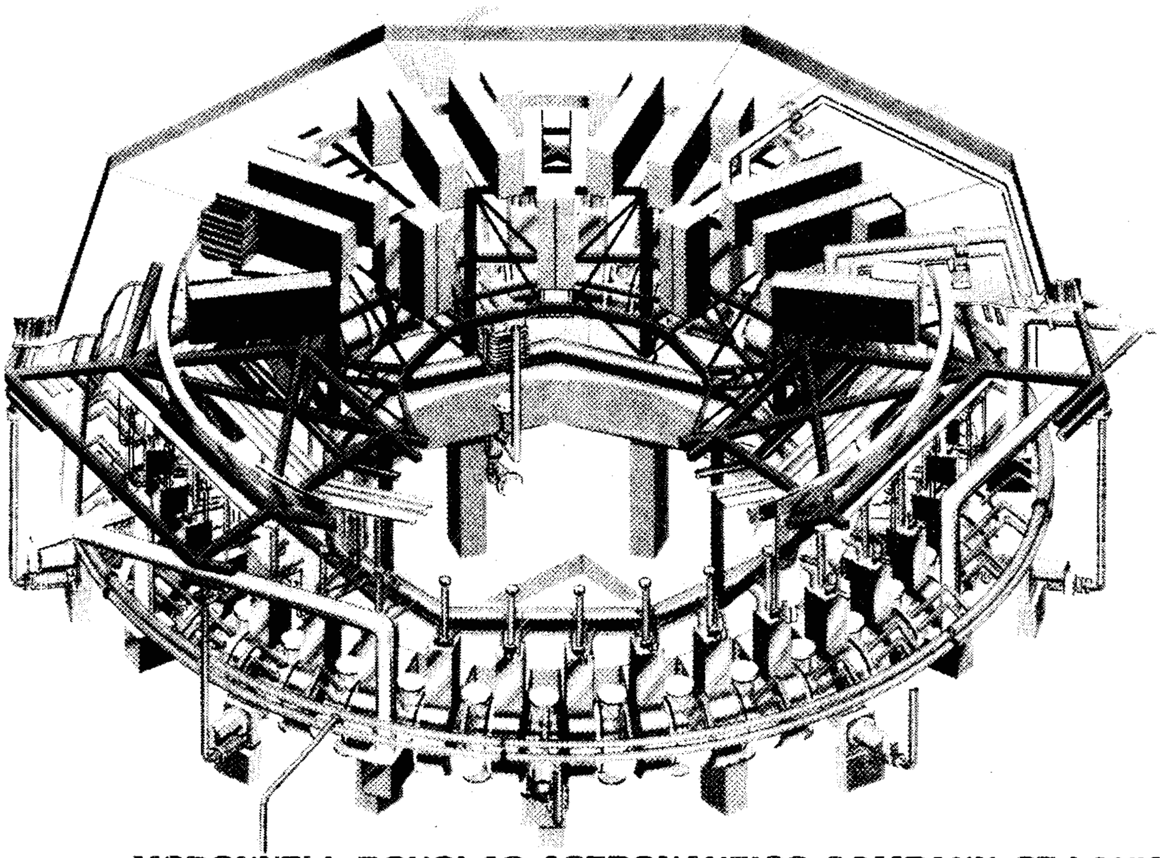
REPORT EBT-P010

FUSION ELMO BUMPY TORUS ENERGY

Copy No. 11

Elmo Bumpy Torus Proof Of Principle

PHASE II — TITLE 1 REPORT
Volume VIII DEVICE UTILITIES



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MCDONNELL DOUGLAS CORPORATION

PRELIMINARY DESIGN REPORT

DEVICE UTILITIES

VOLUME VIII

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

A	Amperes or aspect ratio
ac	Alternating Current
A/E	Architect/Engineer
ARE	Aspect Ratio Enhancement
ASA	American Standards Association
ATM	Atmosphere
BLDG	Building
CCW	Counter Clockwise
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CFM	Cubic Feet per Minute
CG	Center of Gravity
CMD	Command
CNR	Change Notice/Request
CRES	Corrosion Resistant Steel
CVT	Constant-Voltage Transformer
CW	Clockwise
DAS	Data Acquisition System
dB	Decibel
dc	Direct Current
DM	Demineralized
DOE	Department of Energy
DWG	Drawing
EBT-P	Elmo Bumpy Torus - Proof of Principle
ECRH	Electron Cyclotron Resonance Heating
GAI	Gilbert Associates Incorporated
G/C	Gilbert/Commonwealth
GFECC	Global Field Error Correction Coil
GHe	Gaseous Helium
GH_2	Gaseous Hydrogen

GN_2	Gaseous Nitrogen
GPM	Gallons Per Month
HP	Horsepower
HVAC	Heating Venting and Airconditioning
IC	Integrated Circuit
I&C	Instrumentation and Control
ICRH	Ion Cyclotron Resonance Heating
ID	Inside Diameter
I/F	Interface
k	Kilo, i.e., 10^3
LHe	Liquid Helium
LN_2	Liquid Nitrogen
LOI	Letter of Intent
m	Milli, i.e., 10^{-3}
M	Mega, i.e., 10^6
MDAC	McDonnell Douglas Astronautics Company - St. Louis Division
MDC	McDonnell Douglas Corporation
MEB	Mechanical Equipment Building
N/A	Not Applicable
NDE	Non-Destructive Evaluation
OD	Outer Diameter
OR	Oak Ridge
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORVIP	Oak Ridge Valley Industrial Park
OSHA	Occupational Safety and Health Act
PDC	Proposed Design Change
PDR	Preliminary Design Review
PO	Purchase Order
PPM	Parts Per Million

PSF	Pounds Per Square Foot
PSIA	Pounds Per Square Inch Absolute
PSIG	Pounds Per Square Inch Gauge
PWR	Power
QA	Quality Assurance
QC	Quality Control
RF	Radio Frequency
RFP	Request for Proposal
RPM	Revolutions Per Minute
S/C	Subcontractor or Superconductor
SCD	Specification Control Drawing
SDID	Subcontractor Data Item Description
SDRL	Subcontractor Data Requirements List
SCFM	Standard Cubic Feet Per Minute
SSOW	Subcontractor Statement of Work
TBD	To Be Determined
TSB	Test Support Building
U	Utility
UCC-ND	Union Carbide Corporation - Nuclear Division
V	Voltage or Volume
V_{ac}	Volts Alternating Current
V_{dc}	Volts Direct Current
WBS	Work Breakdown Structure
WK	Week
W	Watt
Y-12	ORNL Fusion Facility Location at Oak Ridge

REVISION NOTES

Rev. A 14 October 1981

NOTE

This revision affects the following pages: 2, 108, 110, 113, 114; Appendix A, Pages 4, 15 and 42.

These changes in conjunction with letter EBT-00139, R. J. DeBellis to A. L. Boch, Letter Subcontract #22X-21099C EBT-P Phase II - Preliminary Design Report revision, Device Utilities, Volume VIII, satisfy all of requirements specified within A. L. Boch to R. J. DeBellis, Preliminary Design Report EBT-P Device Utilities, Volume VIII, dated 25 August 1981.

Rev. B 29 January 1982
Incorporates revisions and updates based upon revisions and current Title II design status.

Rev. C 6 April 1982
Incorporates ORNL review comments dated 25 March 1981 and amended by a 6 April 82 J. Stout/R. Hamilton/D. Erickson telecon.

1.0 INTRODUCTION AND SUMMARY

This report describes the activities conducted during the Preliminary Design Period for the Device Utilities Systems. The Device Utilities criteria is defined within Procurement Specification 70P374002 prepared by MDAC-St. Louis and released on 18 December 1980. This specification was formally transmitted to Gilbert Associates Incorporated (GAI) by Letter of Intent of Purchase Order Y1E028R dated 23 March 1981. ORNL review comments to the 70P374002 specification were transmitted to MDAC-St. Louis by UCC-ND letter dated 27 February 1981. These comments have been incorporated within the D revision now in the preparation process. (A draft copy is in contained in Appendix A.) GAI started their Device Utility Preliminary Design effort on 2 January 1981 and satisfactorily completed it on 30 June.

All GAI preliminary specifications, drawings, and reports (listed in Section 4.0) have been transmitted to ORNL for review and approval.

Device Utility Systems Descriptions are also presented in Section 4.0 of this report.

The GAI Device Enclosure Gamma Radiation Analysis is presented in Appendix B.

Pending design criteria revisions are described in Section 6.0. A type B Change Notice Request (CNR) has been transmitted to GAI. The Type B CNR authorizes cost and schedule assessment for each revision identified. Formal Proposed Design Changes (PDC's) will be provided to ORNL when this data is available.

The start of Title II Detail Design is scheduled for 3 August 1981 contingent upon receipt of ORNL approval to proceed.

2.0 PURPOSE AND SCOPE

This report and the PDR, scheduled for 14 July 1981, are provided to assess the Device Utilities Preliminary Design effort. Pending satisfactory assessment of this effort approval from ORNL will be obtained. This approval will permit the start of the Device Utility detail design effort.

The scope of this report and the related PDR will include review of the design criteria, preliminary design specifications, drawings, system descriptions, and analyses.

The Preliminary Design Review is scheduled on 14 July 1981 in St. Louis. The agenda for this review is:

1. Introduction
2. Purpose and Scope
3. Design Criteria Descriptions Summary
4. Desecription of Pending Changes
5. Discussion and Disposition of ORNL Comments
6. Questions and Answers
7. Draft Review Minutes/Assign Action Items
8. Wrap-Up and Summary

It is anticipated that ORNL approval to proceed with Title II Detail Design will be obtained at the conclusion of the review.

3.0 DESIGN CRITERIA

A draft copy of Device Utility Procurement Specification 70P374002 Revision D is provided in Appendix A to fully describe the detail design criteria.

The following provides a design criteria summary.

3.1 Device Enclosure

a. The device enclosure shall provide an environmentally-controlled and biologically-shielded space for the device toroidal vessel and ancillary equipment. Design provisions for personnel safety shall meet the requirements listed in the approved Preliminary Safety Analysis Report.

b. The device enclosure shall contain two (2) levels for personnel access to gyrotron/microwave distribution, diagnostic, and toroidal vessel systems.

c. The device enclosure shall provide for personnel and equipment ingress/egress.

d. The device enclosure shall include lighting, emergency lighting, and fire detection/protection.

e. The device enclosure shall provide structural support to the device support structure.

f. The design of the device enclosure penetrations and diagnostic access windows shall have sufficient flexibility to accommodate planned upgrades.

g. The device enclosure shall provide penetrations through the walls and floors for diagnostics, power cables, instrumentation cables, water lines, ICRH transmission cables, HVAC ducts, ECRH waveguides, and vacuum cryogenic lines.

3.2 Demineralized Water

a. Demineralized water shall be provided for cooling the toroidal vessel, limiters, gyrotron rubes, waveguides, and microwave distribution manifolds, ECRH power regulators and crowbars, ICRH amplifiers and antennas, diagnostics, He compressors, and other components as required.

b. The demineralized water headers within the device enclosure shall be stainless steel.

c. The demineralized water system shall condition makeup water and shall maintain necessary water purity during operation.

d. The demineralized water system shall be built from standard components and assemblies, to the largest extent possible.

e. The demineralized water system shall have redundancy where practical.

f. The demineralized water system shall contain inherent expansion capabilities to handle planned EBT-P upgrades with minimum effort. Piping inside the device enclosure shall be sized for maximum upgrade conditions.

3.3 Instrument Air

a. Compressed instrument air shall be provided for valve actuators, tool drives, and other components as required.

b. The instrument air system shall be built from standard components and assemblies.

3.4 Cooling Tower

a. A cooling tower shall be provided for cooling the demineralized water via heat exchangers and for instrument air equipment cooling.

b. The cooling tower water shall be conditioned to prevent the formation of algae, scale, and other deleterious compounds.

c. Cooling tower automatic water makeup shall be provided.

d. The capability to readily add additional cooling capacity to the cooling tower to handle planned EBT-P upgrades shall be provided.

e. Cooling tower system shall be composed of standard components and assemblies.

f. The cooling tower shall be provided with fire protection.

3.5 Electric Power

a. Electrical utility service shall provide device-related power control/distribution and instrumentation/rf grounding.

b. Commercial components shall be used in preference to custom equipment.

c. Standard electrical codes and City of Oak Ridge regulations shall be satisfied.

d. Field cable lengths shall be minimized.

4.0 DESIGN DESCRIPTION

The various device utilities specifications and drawings generated during Title I and the date each was submitted to ORNL is given in Table 4-1. Copies of each drawing submitted are given in Appendix C for ready reference.

In the sections that follow the device demineralized water, cooling tower, instrument/service air, grounding and lightning (both facility and device utility), HVAC systems, and the device enclosure structure are discussed.

Table 4-1

Drawing/Specification Number	Title	Transmittal Date
N/A	EBT-P Project Applicable Codes, Standards, and Design Criteria	5-5-81
SP-501-101	Excavation	4-24-81
SP-502-111	Placement of Concrete	4-24-81
SP-502-113	In-Process Concrete Testing	4-24-81
SP-502-311	Furnish and Deliver Concrete	4-24-81
SP-502-331	Heating, Ventilating, and Air Conditioning	5-5-81
SP-511-349	Control Cables	4-24-81
N/A	Equipment Component List	5-13-81
N/A	Sample Gilbert to Supplier Proposal Package	5-13-81
N/A	Subsurface Investigation and Foundation Study	5-13-81
SP-502-314	Fabricate and Deliver Reinforcing Steel	4-24-81
SP-502-114	Place Reinforcing Steel	4-24-81
N/A	EBT-P PDR Facility Descriptions (Device Enclosure)	5-5-81
SP-375-315	Fabricate and Deliver Stainless Steel Reinforcement	6-4-81
SP-375-319	Heavyweight Concrete	6-4-81
SP-372-343	Batteries, Battery Charger, and Invertor	6-4-81
SP-375-118	Drilled Caissons	6-4-81
SP-375-120	Inspect and Test Drilled Caissons	6-4-81
SP-321-339	Chemical Analysis and Treatment Equipment	6-4-81
SP-371-341	Cooling Water System Purification Equipment	6-5-81
375-413-001(B)	Device Enclosure Plans & Sections	6-4-81
374-302-001	Instrument/Service Air System Fluid System Diagrams	6-5-81

Drawing / Specification Number	Title	Transmittal Date
373-302-001	Cooling Tower System Fluid System Diagram	6-5-81
371-302-002	Demineralized Water Subsystem Fluid System Diagram	6-5-81
511-206-001	One Line Diagram - 13.8 KV Switchgear	5-26-81
511-206-030	Main One Line, Diagram - 13.8 KV, 2.4 KV, 480 V	5-26-81
370-302-001	Fluid System Diagrams Symbols	11-12-81
75-413-002	Device Enclosure Penetration Details	10-22-81
371-302-003	Demineralized Water and Cooling Tower Subsystems Fluid System Diagrams	6-5-81
371-302-001	Demineralized Water System Fluid System Diagram	6-5-81
SP-371-335	Instrument and Control Devices	6-9-81
SP-372-346	2.4 KV Motor Controller	6-9-81
GAI-302-001	Preliminary System Design Description - Cooling Tower System	6-4-81
SP-371-331	Pumps	6-1-81
SP-371-332	Pipe	5-8-81
SP-371-333	Valves	5-8-81
SP-371-334	Tanks	6-1-81
SP-371-336	Heat Exchangers	6-1-81
SP-373-331	Cooling Tower	5-8-81
SP-373-332	Automatic Water Strainer	6-1-81
SP-374-331	Air Compressor	6-1-81
SP-374-332	Instrument Air Dryer	6-1-81

GAI Fluid System Diagrams - 371-302-001
371-302-002
371-302-003

PRELIMINARY SYSTEM DESIGN DESCRIPTION

DEVICE UTILITIES DEMINERALIZED WATER SYSTEM

Prepared for

ELMO BUMPY TORUS
PROOF OF PRINCIPLE - TEST FACILITY
McDONNELL DOUGLAS ASTRONAUTICS COMPANY

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1.0 INTRODUCTION

This document provides a description of the Demineralized Water System and Support Subsystems for the Elmo Bumpy Torus Proof-of-Principle Test Facility. The document identifies the functions, design requirements, and design intent of the system in addition to describing the system, components, instrumentation and control, modes of operation, safety precautions, and maintenance requirements.

1.1 SYSTEM FUNCTIONS

The function of the Demineralized Water System is to provide cooling for systems such as the toroidal vessel, the microwave system, and helium liquefaction/refrigeration system.

1.2 DESIGN CRITERIA

1.2.1 Chemistry

a. Municipal Water Supply

(1)	pH	7.2
(2)	Conductivity	350 micromhos
(3)	Calcium	39 ppm
(4)	Sulfates	9 ppm
(5)	Alkalinity	108 ppm as $CaCO_3$
(6)	Silica	6 ppm
(7)	Total dissolved solids	230 ppm

b. Demineralized Cooling Water

(1)	pH	6 - 8.5
(2)	Conductivity	<0.1 micromho
(3)	Sodium	<0.1 ppm
(4)	Chloride	<0.1 ppm
(5)	Total dissolved solids	<0.2 ppm
(6)	Dissolved oxygen	<0.5 ppm

c. Demineralized Makeup Water

(1)	pH	6 - 8
(2)	Conductivity	5 micromhos
(3)	Sodium	<1 ppm
(4)	Chloride	<1.5 ppm
(5)	Total dissolved solids	<2.5 ppm
(6)	Dissolved oxygen	<0.5 ppm

1.2.1.1 Normal losses are estimated by MDAC at 50 gpd due to operational leakage.

1.2.1.2 The life of the Facility is estimated at 10 years.

1.2.1.3 The cooling water is provided to the devices at 100° F with a maximum temperature increase of 18° F.

1.2.1.4 The normal design heat loads are:

a.	Toroidal Vessel	1.6 MW
b.	Electron Cyclotron Resonance Heating System (ECRH)	6.7 MW
c.	Helium Compressors	2.0 MW
d.	Ion Cyclotron Resonance Heating System (ICRH)	2.0 MW
e.	Global Field Error Correction Coils (GFECC)	0.5 MW

1.2.1.5 Auxiliary cooling and recirculation heat load is 2.0 MW to the helium compressor and only recirculation to the ECRH.

1.2.1.6 Samples are taken as noted on Table 1.

1.2.2 Design Codes and Standards

1. American National Standards Institute (ANSI):

   a. B16.5, "Steel Pipe Flanges, Flanged Valves, and Fittings."

   b. B16.11, "Forged Steel Fittings, Socket Welding and Threaded."

c. B16.22, "Wrought Copper and Bronze Solder-Joint Pressure Fittings."

d. B18.2.1, "Square and Hex Bolts and Screws, Including Askew Head Bolts, Hex Cap Screws, and Lag Screws."

e. B18.2.2, "Square and Hex Nuts."

f. B36.19, "Stainless Steel Pipe."

2. American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code:

   Section VIII, "Pressure Vessels," Division 1.

3. American Society for Testing and Materials (ASTM):

   a. A-6, "Specification for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use."

   b. A-36, "Specification for Structural Steel."

   c. A-182, "Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service."

   d. A-193, "Specification for Alloy-Steel and Welded Austenitic Stainless Steel Pipe."

   e. A-194, "Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service."

   f. A-213, "Specification for Seamless Ferritic and Austenitic Alloy Steel Boiler, Superheater, and Heat Exchanger Tubes."

   g. A-240, "Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Fusion-Welded Unfired Pressure Vessels."

   h. A-283, "Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, Shapes, and Bars."

   i. A-312, "Specification for Seamless and Welded Austenitic Stainless Steel Pipe."

   j. C-582, "Specification for Reinforced Plastic Laminate for Self-Supporting Structures for Use in a Chemical Environment."

   k. D-3299, "Specification for Filament-Wound Glass Fiber Reinforced Polyester Chemical Resistant Tanks."

4. American Welding Society (AWS):

   D10.4-66, "Welding of Austenitic Chromium-Nickel Steel Piping and Tubing.

5. American Water Works Association (AWWA):

   D-100, "Steel Tanks-Standpipes, Reservoirs, and Elevated Tanks for Water Storage."

6. Hydraulic Institute (HI) Standards.

7. National Electrical Manufacturers Association (NEMA):

   ICS, Part 1-110, "Enclosures."

8. Steel Structures Painting Council (SSPC):

   a. SP1, "Solvent Cleaning."

   b. SP6, "Commercial Blast Cleaning."

1.3 SUMMARY DESCRIPTION

The Demineralized Water Cooling subsystem cools, filters, and circulates demineralized water through the EBT devices. The system has the capability of being switched to auxiliary cooling when reduced heat loads are required.

Approximately 5% of the flow through the heat exchangers will be diverted to the purification subsystem where the water will be passed through a mixed bed demineralizer to remove small amounts of dissolved ions.

A surge tank will provide surge capacity for thermal expansion during heating or cooling of the cycle. The extra capacity will allow the system to undergo some loss of inventory. When makeup water will be required,

The entire contents of the tank will be injected into the purification loop. Passing the makeup water through the purification demineralizer will provide polishing of the water.

After a period of service the purification demineralizer will require regeneration. This is due to the loss of resin capacity, buildup of crud, or loss of bed effectiveness due to localized channeling in the vessel. The demineralizer will be removed from service by bypassing the entire flow. A separate supply of degassed demineralized water will be provided. The water will be pumped from the storage tank through a vacuum degasifier by the demineralizer regeneration water pump. Solutions of acid and caustic will be prepared in measuring tanks. An air blower will provide air for vessel blowdown and for resin mixing.

All low flow and gravity drains will go to the waste neutralizing tank. High rate-high volume wastes will be pumped directly to the neutralizing tank. After the regeneration sequence has been completed, the tank contents will be neutralized using either acid or caustic. Ejector type sparges will be used in the tank for mixing. When the waste has been neutralized, it will be discharged to the local drain system.

A dilute hydrazine solution will be pumped into the cooling water to scavenge dissolved oxygen.

Partially demineralized water, provided by rented water demineralizers, will be delivered to the demineralized water storage tank. The available inventory will be between 25,000 and 50,000 gallons.

An automatic sampling system will provide the monitoring and control required to maintain the required water chemistry.

2.0 DETAILED DESCRIPTION

2.1 COMPONENTS

2.1.1 Demineralized Water Surge Tank

The Demineralized Water Surge Tank provides surge capacity for the system. The vessel is pressurized with nitrogen to insure a sufficient net positive suction head at the pumps. Details are listed below.

Quantity	1
Tag No.	371MTK001
Height, straight side	
Diameter	
Working capacity	
Design code	
Construction material	
Connections	
Design pressure	
Design temperature	
Manufacturer	
GAI Specification No.	

2.1.2 Demineralized Water Main Pumps

The Demineralized Water Main Pumps circulate demineralized water for cooling the Device components. Each pump is 50% of the total system capacity. Details are listed below.

Quantity	2 (50%)
Tag No.	371MPP001 371MPP002
Design code	
Manufacturer/Model	
Type	
Capacity (each pump)	
Design discharge head	
Material (wetted parts)	
Motor HP/volts/hertz/phase/RPM	
GAI Specification No.	

2.1.3 Demineralized Water Auxiliary Pump

The Demineralized Water Auxiliary Pump circulates demineralized water for cooling the helium compressors and provides circulation to the ECHR units. Details are listed below.

Quantity	1
Tag No.	371MPP003
Design Code	
Manufacturer/Model	
Type	
Capacity	
Design discharge head	
Material (wetted parts)	
Motor HP/volts/hertz/phase/RPM	
GAI Specification No.	

2.1.4 Demineralized Water Main Heat Exchanger

The Demineralized Water Main Heat Exchanger cools the main circulating water flow and rejects the heat to the Cooling Tower System. Details are listed below.

Quantity	2
Tag No.	371MHX001/371MHX002
Type	Shell and Tube or Plate
Control	
Construction material	
Design pressure	225 psig
Design temperature	150^{o}F
Design code/class	
Design flow	3600 GPM/Unit
Duty, max. design	17 MW
Maximum ΔT	18^{o}F
GAI Specification No.	SP-371-336

2.1.5 Auxiliary Heat Exchanger - Deleted (see 2.1.4)

The Auxiliary Heat Exchanger cools the water pumped by the Auxiliary Pump. The heat is rejected to the Cooling Tower System. Details are listed below.

Quantity

Tag No.

Type

Construction material

Design pressure

Design temperature

Design code/class

Design flow

Duty, max. design	
Maximum ΔT	
GAI Specification No.	

2.1.6 100 Micron Filter

The 100 Micron Filter removes particles greater than 100 microns in size from the main cooling loop. Details are listed below.

Quantity	2
Tag No.	371MFL001/371MFL002
Type	
Volume	
Design pressure	175 psig
Design temperature	100°F
Design Code/Class	
GAI Specification No.	SP-371-341
Construction material	
Filtering capacity	6700 GPM/Unit
Micron size	100 micron

2.1.7 Demineralized Water Purification Demineralizer

The Demineralized Water Purification Demineralizer removes ionic impurities from the purification loop and polishes the makeup to the cycle. An air blower is provided to thoroughly mix the resins after regeneration. The unit is fitted with filter silencers. Details are listed below.

Quantity	1
Tag No.	371MDM001
Design Code	
Manufacturer	
Capacity	900 GPM

Design pressure	150 psig
Design temperature	100°F
Diameter	
Straight side	
Lining	
Connections	
Volume of anion resin (each unit)	
Volume of cation resin (each unit)	
Type anion resin	
Type cation resin	
Minimum net throughput per regeneration (each unit)	
Material	
GAI Specification No.	ASTM A 285, Grade C or T SP-371-341

2.1.8 Demineralized Water Makeup Degasifier

The Demineralized Water Makeup Degasifier degasifies demineralized water from the demineralized water storage tank. Details are listed below.

Quantity	1
Tag No.	371MDA001
Type	Vacuum
Design Code	
Manufacturer	
Capacity (maximum)	200 GPM
Design pressure, psig	Full Vacuum
Design temperature	40°F to 85°F

Diameter	tower basin	
Straight side	tower basin	
Lining		Plasite 7155 or approved equal ASTM A 285 grade C or T
Material		
Reservoir Storage (min.)		1,000 Gal's
GAI Specification No.		SP-371-341

2.1.9 Demineralized Water Makeup Degasifier Vacuum Pump

The Demineralized Water Makeup Degasifier Vacuum Pump produces a vacuum in the degasifier removing dissolved gases from the demineralized water. Details are listed below.

Quantity	1
Tag No.	371MVP001
Manufacturer/Model	Nash or approved equal
Type	
Design pressure	
Manufacturer/Model	
Capacity (22° C, 0 kg/cm^2 gauge)	
Discharge pressure	
Design temperature	
Motor/HP/volts/hertz/phase/RPM	40^oF to 85^oF
GAI Specification No.	SP-371-341

2.1.10 Demineralizer Regeneration Water Pump

The Demineralizer Regeneration Water Pump pumps demineralized water from the storage tank and through the degasifier. It provides pressurized-degasified demineralized water to the cycle for startup and emergency and to the demineralizer for regeneration.

Quantity	1
Tag No.	371MPP004

Design code

Manufacturer/Model

Type

Capacity

Design discharge head

Material (wetted parts)

Motor HP/volts/hertz/phase/RPM

GAI Specification No.

2.1.11 Demineralized Water Makeup Injection Package - Deleted

2.1.12 Demineralized Water Storage Tank

The Demineralized Water Storage Tank contains two-bed demineralized water and is used for makeup and other demand requirements of the cooling water loop. Details are listed below.

Quantity	
Tag No.	371MTK002
Height, straight side	
Diameter	
Working capacity	
Design Code	
Material of construction	
Connections	
Design pressure	
Design temperature	
Manufacturer	
GAI Specification No.	

2.1.13 Demineralized Water Hydrazine Treatment Package

The Demineralized Water Hydrazine Treatment Package provides a dilute hydrazine solution at a controlled rate to the demineralized water cooling loop. The pump is controlled by a signal proportional to the hydrazine concentration in the loop. Details are listed below.

Quantity	1
Skid Tag No.	371MAA001
Skid dimensions	
Structural weight	
Gross weight	
Solution Tank Manufacturer	
Capacity	
Material	
Type	
Injection Pump Manufacturer/Model	
Type	
Capacity	
Discharge Pressure	
Materials: wetted parts	
diaphragm	
Motor Manufacturer	
Motor HP/volts/hertz/phase/rpm	

2.1.14 Hydrazine Storage Transfer Pump

The Hydrazine Storage Transfer Pump pumps 35% hydrazine from its shipping container in the chemical storage area to the hydrazine treatment package. Details are listed below.

Quantity	1
Tag No.	371MPP006
Manufacturer/Model	

Type

Capacity

Discharge Pressure

Materials: wetted parts

diaphragm

Motor Manufacturer

Motor HP/volts/hertz/phase/rpm

2.1.15 Waste Neutralizing Tank

All plant aqueous wastes are delivered to the Waste Neutralizing Tank. The contents are monitored and periodically neutralized and discharged locally. Details are listed below.

Quantity	1
Tag No.	371MTK003
Height, straight side	As required
Diameter	12' - 0"
Working capacity	15,000 Gal.
Design code	
Construction material	
Connections	
Design pressure	Atmospheric
Design temperature	
Manufacturer	
GAI Specification No.	SP-371-341

2.1.16 Waste Neutralizing Tank Discharge Pump

The Waste Neutralizing Tank Discharge Pump recirculates the contents of the neutralizing tank to assure proper mixing before discharging. Details are listed below.

Quantity	1

Tag No.	371MPP010
Design Code	
Manufacturer/Model	
Type	
Capacity	200 GPM
Design discharge head	50 Ft. TDH
Material (wetted parts)	316 Stainless STeel and/or Chemical Resistant FRP
Motor HP/volts/hertz/phase/rpm	
GAI Specification No.	SP-371-341

2.1.17 Waste-Gravity Drain Tank - Deleted

2.1.18 Waste-Gravity Drain Tank Transfer Pump

The Waste-Gravity Drain Tank Transfer Pump transfers the contents of the drain tank to the waste neutralizing tank. Details are listed below.

Quantity	1

Tag No.	371MPP005
Design Code	
Manufacturer/Model	
Type	
Capacity	200 GPM
Design discharge head	60 FT TDH
Material (wetted parts)	316 STAINLESS STEEL OR CHEMICAL RESISTANT FRP
Motor HP/volts/hertz/phase/rpm	
GAI Specification No.	SP-371-341

2.1.19 Acid Storage Tank

The Acid Storage Tank receives and stores a shipment of sulfuric acid. The acid is used for cooling tower and demineralized water treatment. Details are listed below.

Quantity	1
Tag No.	371MTK005
Height, straight side	
Diameter	
Working capacity	
Design code	
Construction material	
Connections	
Design pressure	
Design temperature	
Manufacturer	
GAI Specification No.	

2.1.20 Acid Tank Transfer Pump

The Acid Tank Transfer Pump transfers acid from the acid storage tank to the cooling tower treatment package, the purification demineralizer, or the water neutralizing tank as required. Details are listed below.

Quantity	1
Tag No.	371MPP007
Manufacturer/Model	
Type	
Capacity	
Discharge pressure	
Materials: wetted parts	
diaphragm	
Motor manufacturer	
Motor HP/volts/hertz/phase/rpm	

2.1.21 Caustic Storage Transfer Pump

The caustic storage transfer pump transfers 50% caustic from its shipping vessel to the purification demineralizer or the waste neutralizing tank as required. Details are listed below.

Quantity	1
Tag No.	371MPP008
Manufacturer/Model	
Type	
Capacity	
Discharge pressure	
Materials: wetted parts	
diaphragm	
Motor manufacturer	
Motor HP/volts/hertz/phase/rpm	

2.1.22 <u>Sampling and Analysis Panel</u>

The Sampling and Analysis Panel instrumentation and analysis equipment analyzes the cooling tower and cooling water samples on either a continuous or intermittent basis. Details are listed below.

Panel:

Quantity	1
Tag No.	371ECP001
Manufacturer	
Panel dimensions (L x W x H)	
Sink dimensions	
Sink material and thickness	
Recovery header size	
Recovery header material	
Panel Material	
Panel Weight	
GAI Specification No.	

Conductivity Analysis Equipment:

Conductivity measurements, as indicated, are made at the Sampling Panel on the following samples.

1. Main cooling loop, cation conductivity
2. Purification loop inlet, cation conductivity
3. Purification loop outlet, cation conductivity
4. Demineralizer regeneration water, cation conductivity
5. Cooling tower, conventional conductivity

Cation Conductivity Analyzer, including resin column and cell:

Quantity	4
Manufacturer	

Model

Conductivity cell

Type

Cation Conductivity Indicating Transmitter:

Quantity	4
Manufacturer	
Model	
Range	
Output	
Alarm contacts	

Conventional Conductivity Cells:

Quantity	1
Manufacturer	
Model	
Cell holder	

Conventional Conductivity Indicating Transmitter:

Quantity	1
Manufacturer	
Model	
Range	
Output, measuring control	
Alarm contacts	

pH Analysis Equipment:

This equipment measures pH on the following samples.

1. Main cooling loop
2. Neutralizing tank
3. Cooling tower

pH Cell Assemblies:

Quantity	3
Manufacturer	
Model	
Type	
Measuring Electrode Model	
Reference Electrode	
Reference Electrode Model	

pH Indicating Transmitters:

Quantity	
Manufacturer	
Model	
Range	
Output	
Alarm Contacts	

Hydrazine Analysis Equipment

This equipment measures hydrazine concentration of the main cooling loop sample.

Quantity	1
Manufacturer	
Model	
Type	
Range	
Signal Output	
Reagent	
Control Output	
Alarm Contacts	

Dissolved Oxygen Analysis Equipment

This equipment measures dissolved oxygen concentration on the following samples:

1. Main cooling loop/demineralizer regeneration water

2. Purification loop outlet

Quantity	1
Manufacturer	
Model	
Type	
Range	
Signal Output	
Alarm Contacts	

Chlorine Analysis Equipment:

This equipment measures residual chlorine of the cooling tower sample.

Quantity	1
Manufacturer	
Model	
Type	
Range	
Signal Output	
Alarm Contacts	

Recorders:

1. Recorder #1, cation conductivity

   Recorder #1 records conductivity for the following:

   a. Main cooling loop

   b. Demineralizer regeneration water

Manufacturer

Model

Type Dual pen

Chart speed

Input signal

Scale

2. Recorcer #2, cation conductivity

Recorder #2 records conductivity for the following:

a. Purification loop inlet

b. Purification loop outlet

Manufacturer

Model

Type Dual pen

Chart speed

Input signal

Scale

3. Recorder #3, pH

Recorder #3 records pH for the following:

a. Main cooling loop

b. Neutralizing tank

Manufacturer

Model

Type Dual pen

Chart speed

Input signal

Scale

4. Recorder #4, dissolved oxygen

Recorder #4 records dissolved oxygen for the following:

a. Main cooling loop/demineralizer regeneration water

b. Purification loop outlet

Manufacturer	
Model	
Type	Dual pen
Chart speed	
Input signal	
Scale	

5. Recorder #5, hydrazine

Recorder #5 records hydrazine for the main cooling loop sample.

Manufacturer	
Model	
Type	Single pen
Chart speed	
Input signal	
Scale	

6. Recorder #6, cooling tower conductivity

Recorder #6 records the cooling tower conductivity.

Manufacturer	
Model	
Type	Single pen
Chart speed	
Input signal	
Scale	

7. Recorder #7, cooling tower pH

Recorder #7 records the cooling tower pH.

Manufacturer	
Model	
Type	Single pen
Chart speed	
Input signal	
Scale	

8. Recorder #8, cooling tower residual chlorine

Recorder #8 records the cooling tower residual chlorine.

Manufacturer	
Model	
Type	Single pen
Chart speed	
Input signal	
Scale	

Annunciator:

A twenty (20) point, panel mounted annunciator is supplied to alert Facility personnel of problems in the cooling loop and cooling tower chemistry or in the operation of the sampling system. Annunciator windows are provided for the following:

a.	Cooling tower - conductivity	Hi/Lo
b.	Cooling tower - pH	Hi/Lo
c.	Cooling tower - chlorine	Hi/Lo
d.	Neutralizing tank - pH	Hi/Lo
e.	Demineralized regeneration water - cation conductivity	Hi
f.	Main loop - DO	Hi

g.	Demineralized regeneration water - dissolved oxygen	Lo
h.	Main loop - cation conductivity	Hi
i.	Main loop - pH	Hi/Lo
j.	Main loop - hydrazine	Hi
k.	Purification loop inlet - cation conductivity	Hi
l.	Purification loop outlet - cation conductivity	Hi
m.	Purification loop outlet - dissolved oxygen	Hi/Lo
n.	Demineralized water hydrazine treatment tank - level	Hi/Lo
o.	Demineralized water makeup injection tank - level	Hi/Hi
p.	Chilled water treatment tank - level	Hi/Lo
q.	Cooling tower chlorine tank - level	Hi/Lo
r.	Cooling tower acid tank - level	Hi/Lo

1. Manufacturer
2. Model
3. Arrangement
4. Nameplates
5. Accessories
6. Operating sequence

Condition	Visual	Audible
a. Normal	Off	Off
b. Alert	Flashing	On
c. Acknowledged	On	Off

Condition		Visual	Audible
d.	Return to normal	Off	Off
e.	Multiple alert, first condition acknowledged	Flashing	On

Controllers:

1. Controller #1

   Controller #1 receives a signal from the cooling tower conventional conductivity analyzer. The controller output modulates the cooling tower blowdown valve.

2. Controller #2

   Controller #2 receives a signal from the cooling tower pH analyzer. The controller output controls the cooling tower acid treatment package injection pump.

3. Controller #3

   Controller #3 receives a signal from the demineralized water cooling loop hydrazine analyzer. The controller output controls the demineralized water hydrazine treatment package injection pump.

2.2 INSTRUMENTS, CONTROLS, ALARMS, AND PROTECTIVE DEVICES

2.2.1 Pressure Indicators

Pressure indicators are provided at the following locations. Local indicators are provided with isolation valves.

a. Surge tank total pressure, panel mounted

b. Auxilary pump suction, local

c. Main pumps A and B suction, local

d. Auxiliary pump discharge, panel mounted and local

e. Main pumps A and B discharge, local

f. Main pumps A and B common discharge, panel mounted and local

g. Purification loop inlet, panel mounted

h. Purification demineralizer inlet, local

i. Demineralizer regeneration water pump discharge, local

j. Demineralized water makeup degasifier vacuum, local

k. Demineralized water makeup injection package transfer pump discharge, local

l. Demineralized water makeup injection package injection pump discharge, local

m. Waste-gravity drain tank transfer pump discharge, local

n. Waste neutralizing tank transfer pump discharge, local

o. Acid storage transfer pump discharge, local

p. Caustic storage transfer pump discharge, local

q. Hydrazine storage transfer pump discharge, local

r. Demineralized water hydrazine treatment package injection pump discharge, local

s. Sampling panel sample inlets, local panel

t. Purification demineralizer air blower discharge, local

2.2.2 Pressure Transmitters

Pressure transmitters with isolation valves are provided at the following locations:

a. Surge tank total pressure

b. Auxiliary pump discharge

c. Main pumps A and B common discharge

d. Purification loop inlet

2.2.3 Pressure Switches

Pressure switches with isolation vlaves are provided at the following locations:

a. Surge tank, open nitrogen inlet

b. 50 micron filter, high differential pressure

c. Purification demineralizer, high differential pressure

d. Demineralized water makeup degasifier, high vacuum

2.2.4 Temperature Indicators

Temperature indicators are provided at the following locations:

a. Auxiliary heat exchanger outlet, panel mounted and local

b. Main heat exchanger outlet, panel mounted and local

c. Purification loop outlet, panel mounted and local

d. Demineralized water storage tank, panel mounted and local

e. Waste neutralizing tank, panel mounted and local

f. Acid storage tank, panel mounted and local

g. Demineralized water pump suction, local

2.2.5 Temperature Transmitters

Temperature transmitters are provided at the following locations:

a. Auxiliary heat exchanger outlet

b. Main heat exchanger outlet

c. Purification loop outlet

d. Demineralized water storage tank

e. Waste neutralizing tank

f. Acid storage tank

g. Demineralized water pump suction

2.2.6 Temperature Controllers

Temperature controllers are provided on the panel for:

a. Auxiliary heat exchange outlet, control bypass valve

b. Main heat exchanger outlet, control bypass valve

c. Demineralized water storage tank, control heater

2.2.7 Flow Indicators

Flow indicators are provided at the following locations. Local indicators are provided with throttling valves.

a. Demineralized water cooling loop, panel mounted

b. Purification loop inlet, panel mounted

c. Purification demineralizer air blower, panel mounted

d. Sampling panel analyzer inlets, local

2.2.8 Flow Element - Transmitters

Flow elements and transmitters are provided at the following locations:

a. Demineralized water cooling loop

b. Purification loop inlet

c. Purification demineralizer inlet

d. Purification demineralizer air blower

2.2.9 Flow Totalizer

A flow totalizer for measuring the throughput to the purification demineralizer is located on the panel.

2.2.10 Flow Controller

A flow controller for controlling the operation of the purification loop inlet and bypass valves is located on the panel. The controller maintains a constant flow through the demineralizer or bypass.

2.2.11 Level Indicators

Level indicators are provided at the following locations. Local gage glasses are providedd with isolation valves.

a. Surge tank, gage

b. Demineralized water makeup degasifier, panel mounted

c. Demineralized water storage tank, panel mounted and local

d. Waste neutrlaizing tank, panel mounted and local

e. Acid storage tank, panel mounted and local

f. Demineralized water hydrazine treatment package solution tank, gage

2.2.12 Level Transmitter

Level transmitters are provided at the following locations:

a. Surge tank

b. Demineralized water makeup degasifier

c. Demineralized water storage tank

d. Waste neutralizing tank

e. Acid storage tank

2.2.13 Level Switches

Level switches are provided at the following locations:

a. Surge tank, open emergency makeup water valve

b. Demineralized water makeup degasifier, low level alarm

c. Acid storage tank, high and low level alarm

d. Waste - gravity drain tank transfer pump cutoff

e. Demineralized water hydrazine treatment package injection pump cutoff

2.2.14 Level Controller

Level controllers are provided on the panel for:

a. Demineralized water makeup degasifier level to control inlet valve.

b. Demineralized water storage tank level to close inlet valve.

2.2.15 Analysis Elements

Analysis elements are provided for:

a. Purification demineralizer outlet, conventional conductivity, local.

b. Analysis elements as listed in Section 2.1.22.

2.2.16 Analysis Indicating Transmitters

Analysis indicating transmitters are provided as listed in Section 2.1.22.

2.2.17 Analysis Controllers

Analysis controllers are provided as listed in Section 2.1.22.

2.2.18 Analysis Recorders

Analysis recorders are provided as listed in Section 2.1.22.

2.2.19 Alarms

Annunciators are provided on the main control panel and the sampling and analyzer panel to alert personnel to operational problems. Sampling and analyzer panel alarms are described in Section 2.1.22.

a. Surge tank, level, low-low

b. 100 micron filters, differential pressure, high

c. Main cooling loop, flow, low

d. Purification demineralizer, differential pressure, high

e. Purification demineralizer, conductivity, high

f. Demineralized water storage tank, temperature, high/low

g. Demineralized water makeup degasifier, vacuum, high

h. Waste-gravity drain tank, level, high

i. Demineralized water makeup degasifier, level, low

j. Waste neutralizing tank, temperature, low

k. Waste neutralizing tank, level, high/low

l. Acid storage tank, level, high/low

2.2.20 Computer Records

Computer records are made of the following parameters:

a. Surge tank level

b. Demineralized water pumps, inlet temperature

c. Auxiliary heat exchanger, outlet temperature

d. Main heat exchanger, outlet temperature

e. Main cooling loop flow

f. Purification loop flow

g. Purification loop outlet temperature

h. Demineralized water storage tank temperature

i. Demineralized water storage tank level

j. Waste neutralizing tank level

k. Cooling tower conductivity

l. Cooling tower pH

m. Cooling tower residual chlorine

n. Neutralizing tank pH

o. Demineralizer regeneration water cation conductivity

p. Main cooling loop dissolved oxygen

q. Main cooling loop cation conductivity

r. Main cooling loop pH

s. Main cooling loop hydrazine

t. Purification loop inlet cation conductivity

u. Purification loop outlet cation conductivity

v. Purification loop outlet dissolved oxygen

2.2.21 Interlocks

a. Normal Makeup

On low surge tank level, makeup injection pump valve opens and makeup injection pump turns on injecting the contents of the tank into the purification loop.

On low makeup tank level, makeup injection pump turns off, makeup injection pump discharge valve closes, dilute hydrazine transfer pump turns on and dilution water valve opens filling the tank.

On high makeup tank level, dilution water valve closes. The dilute hydrazine transfer pump is turned off by a timer.

b. Demineralizer Regeneration

When the regeneration sequence is initiated, the purification loop bypass valve is opened, the purification loop inlet and outlet valves are closed, and the demineralizer inlet valve is closed.

The demineralizer regeneration pump and vacuum pumps are turned on. Solenoid valves are opened on the sampling panel to allow sample to flow to the dissolved oxygen analyzer.

On low oxygen level an alarm is annunciated on the sampling panel. The demineralizer regeneration water discharge valve is opened and the recycle valve is closed manually allowing water to be available on demand at the demineralizer inlet valve.

When regeneration is complete, an alarm is annunciated on on the demineralizer package panelboard. The system is manually returned to its original status and the purification demineralizer placed in service.

c. Emergency Makeup

On low-low surge tank level, the emergency inlet valve is opened and the demineralizer regeneration pump is turned on.

On high surge tank level, the system is returned to its normal status.

d. Waste-Neutralization and Discharge

The waste neutralizing tank discharge pump is turned on and recycled. The sample valve on the panel is set to allow sample to flow to the pH analyzer. Acid or caustic is added to the tank as required.

When the pH is within acceptable limits, the pump discharge valve is manually opened and the recycle valve is manually closed.

On low tank level the system is returned to its original status.

2.2.22 <u>Switches and Protective Devices</u>

a. All pumps are protected by low tank level cutoff switches.

b. All tanks have high or high-high level alarms to alert personnel of overfilling.

3.0 OPERATION

3.1 STARTUP

3.1.1 Initial Fill

The system is manually placed in the "Initial Fill" mode which assures that valves are set and equipment is running so that:

a. A flow path has been established from the demineralized water storage tank to the demineralizer regeneration water pump.

b. A continuous sample is being measured for dissolved oxygen at the sample panel.

c. If required, the device system to be filled is evacuated to less than 1 psia.

d. The cooling system is ready to receive water.

When the dissolved oxygen concentration is at the proper level, the demineralizer regeneration water pump flow is diverted to the purification loop, thus filling the system.

Air is bled from the system as it fills with demineralized water.

3.1.2 Startup from Cold Shutdown

To start the system from a cold shutdown, the following steps must be taken:

a. The hydrazine treatment package is charged and operational.

b. The sampling panel is receiving samples and analyzers and recorders are operational.

c. The makeup injection package is charged and operational.

d. Cooling water is available at the heat exchangers.

The surge tank contents are blanketed with nitrogen under slight positive pressure. One demineralized water main pump is started and flow paths to all devices are established one booster pump is then started.

3.1.3 Startup from Auxiliary Standby

During the auxiliary standby mode, the main pumps are off and isolated with the main heat exchanger from the system. Water is circulated by the auxiliary pump through the auxiliary heat exchanger to devices requiring cooling during shutdown.

The main loop isolation valve is opened and one main pump is started. Devices previously isolated are opened to the system. The auxiliary pump is shut off and the second main pump is started. The auxiliary isolation valve is closed.

3.2 NORMAL OPERATING MODE

During normal operation, heat is rejected to the system from the devices and then rejected to the cooling tower system. For low heat load periods, the heat exchanger may be bypassed.

System heat-up will cause expansion in the surge tank. To compensate for fluctuations, a constant pressure nitrogen blanket is created in the surge tank.

Demineralized water losses occur normally in the system. Normal makeup is added from the makeup injection package. This package is charged on standby and will engage automatically when needed.

Dissolved oxygen is controlled by the addition of hydrazine from the hydrazine treatment package. Hydrazine concentration is measured at the sampling panel and a control signal is sent to the hydrazine pump to control the rate of hydrazine feed.

Approximately 5% of the maximum flow is diverted through the purification demineralizer. The demineralizer removes dissolved impurities and corrosion products generated in the cooling loop. Makeup water is also passed through the demineralizer.

Samples from key points in the system are brought to the sampling panel where conductivity, pH, dissolved oxygen, and hydrazine are measured and recorded.

3.3 SHUTDOWN

3.3.1 Cold Shutdown

To come to a complete or cold shutdown, all devices must be inactive. Shutdown consists of turning off the boost pump. After a period of time and with the assurance that there is no temperature rise, the main pump can be turned off.

All root valves to the treatment packages and sampling are closed. All instruments and analyzers are deactivated.

3.3.2 Partial Shutdown

Partial shutdown or shutdown to the auxiliary cooling mode is accomplished by reversing the operations sequence found in Section 3.1.3.

3.4 SPECIAL OR INFREQUENT OPERATING

3.4.1 Emergency Cooling

If a major leak or line break occurs, a sudden and dramatic loss of water level in the surge tank will cause a flow path to be created, and the demineralizer regeneration water pump to be started, flooding the suction of the main pumps with demineralized water from the storage tank.

3.4.2 Demineralizer Regeneration

When the purification demineralizer requires regeneration, degasified water is made available. Demineralized water from the storage tank is degasified as it is needed by the regeneration sequence. All regeneration operations are automatic, being controlled from the demineralizer package.

4.0 SAFETY

4.1 HAZARDS

Storage and handling of 35 percent hydrazine presents a potential hazard to operating personnel. Extended exposure of personnel to fumes can be harmful.

4.2 PRECAUTIONS

Protective equipment should be worn by operating personnel when handling hydrazine. This should include safety goggles, gloves, rubber boots, and aprons. A safety shower and an eyewash fountain are provided near the chemical feed equipment. These are designed for quick operation in an emergency. Prompt first aid measures must be taken whenever a chemical contacts the body or excessive fumes are inhaled. Chemical spills should be quickly diluted and drained.

The chemical storage area should have good air circulation and venting of chemical feed tanks to outside the building to avoid buildup of harmful vapors.

5.0 MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

Adherence to prescribed operating procedures and periodic checking of equipment controls should result in reliable system operation. Periodic inspections and adjustments suggested by the equipment manufacturers should be performed as prescribed, including:

a. Checking of alarms and system controls.

b. Inspection of motor wiring and checking of supply voltage.

c. Inspection of strainers and suction piping to ensure adequate suction pressure to pump.

d. Checking micrometer adjustment of chemical pumps to ensure good control.

f. Checking for proper valve tolerances and worn or dirty valve seats to ensure pump delivery at rated capacity.

g. Checking pressure relief valves regularly for proper operation.

h. Checking pressure gauge readings.

i. Proper oiling and lubrication of pumps to give smooth, noise-free operation.

j. Checking 100 micron filters ΔP indicators and backflushing when required.

A set of spare parts and special tools suggested by equipment manufacturers should be kept on hand for proper servicing of equipment.

TABLE 1

SAMPLE LIST AND CONDITIONS

Sample	Expected Operating Pressure (at Sampling Room) psig (kg/cm^2)	Expected Operating Temperature °F (°C)	Design Minimum Flow cc/min	(1) Required Analysis pH	CC	C	DO	HZ	CI	(2) Sink	Note
1. Main Cooling Loop	Later	Later	2100	X	X		IX	X		C	
2. Purification Loop Inlet (Makeup Injection)	Later	Later	700		X					C	
3. Purification Loop Outlet	Later	Later	1500		X		X			C	
4. Neutralizing Tank	Later	Later	700	2Y(7)						M	(3)
5. Demineralized Regeneration Water	Later	Later	1550		X		IY			C	(4)
6. Demineralized Water Makeup	Later	Later	500							M	(5)
7. Purification Loop Outlet (Demineralixed Water Supply)	Later	Later	600	2X(7)						M	(6)
8. Cooling Tower	Later	Later	2 gpm	X		X			X	C	

NOTES:

(1) pH = pH
CC = cation conductivity
C = conventional conductivity
DO = Dissolved oxygen
HZ = Hydrazine
CI = Residual chlorine

(2) C = Continuous
M = Manual

(3) Only during neutralization

(4) Only during demineralizer regeneration

(5) Sample off Demineralizer Water Tank

(6) Primarily for flushing analyzers

(7) X = normal sample
Y = alternate sample

PRELIMINARY
SYSTEM DESIGN DESCRIPTION

COOLING TOWER SYSTEM

PREPARED FOR
ELMO BUMPY TORUS
PROOF OF PRINCIPLE - TEST FACILITY

Prepared By
Gilbert Associates, Inc.
P.O. Box 1498
Reading, PA

TABLE OF CONTENTS

1.0 INTRODUCTION

This document presents a description of the Cooling Tower System for the Elmo Bumpy Torus Proof-of-Principle Test Facility which will be constructed in Oak Ridge, Tennessee, for the Department of Energy. The description includes the system design, details of components, controls and instrumentation, functions, operation, and maintenance. The system flow diagram is GAI drawing 373-302-001.

1.1 SYSTEM FUNCTION

The Cooling Tower System supplies cooling water to the Demineralized Water Main Heat Exchangers and the Air Compressor Package. The system consists of a single loop with two 50% circulating water pumps and a multi-cell mechanical draft cooling tower.

1.2 DESIGN REQUIREMENTS

The Cooling Tower System is designed to remove heat from the demineralized water heat exchangers, and the instrument/service air compressor package. The Mechanical Draft Cooling Tower is designed to expell heat to the atmosphere with a temperature change across the tower of 18°F. The cooling tower pumps are sized for the required cooling loads of the above components, with all equipment in service. The cooling water flow requirements are established by the system being cooled.

The system piping and pressure retaining components are designed according to ANSI B31.1 and ANSI B16.5.

1.3 SUMMARY DESCRIPTION

The Cooling Tower System for the EBT-P will consist of a multi-cell mechanical draft cooling tower, two 50% circulating water pumps, an automatic water strainer, a sodium hypochloride and acid treatment package, and associated piping and valves.

The Mechanical Draft Cooling Tower will be a multi-cell, cross-flow tower constructed on a concrete basin. The cooling tower will remove heat from the circulating water by expelling it to the atmosphere. The cooling tower basin will have continuous makeup from Oak Ridge's Municipal Water supply and will have continuous blowdown which is controlled by circulating water's conductivity.

The system's two circulating water pumps will be each 50% capacity pumps. The pumps will circulate water to the demineralized water system's main heat exchangers during the periods when the EBT Device is operating and to just one heat exchanger when the EBT Device is not operating. The pumps also supply flow to the instrument/service air compressor's intercooler and aftercooler. After passing through the above items, the water will be returned to the cooling tower.

An automatic backflush water strainer is located in the piping at the common inlet header of the two circulating water pumps. The strainer will automatically backflush the filter elements whenever the pressure drop across the strainer exceeds its set point pressure drop without interrupting the system's operation.

The Cooling Tower System's circulating water will be chemically controlled with both an acid treatment package and a sodium hypochloride treatment package. The purpose of the acid treatment package will be to control the circulating water's pH. To control fungus, algae, and other growth in the system, the sodium hypochloride treatment package will add a 15% solution through a programmed sequence on a regular basis. Residual chlorine will be monitored by the sampling system and will alert the operator if the chlorine content of the water exceeds predetermined levels.

Motor operated valves will be used to isolate the various components that the Cooling Tower System services. There will be manual valves to isolate either one of the circulating water pumps and the cooling tower inlet and basin outlet.

2.0 DETAILED DESCRIPTION OF SYSTEM

2.1 COMPONENTS

2.1.1 Mechanical Draft Cooling Tower

The EBT-P design includes a multi-cell mechanical draft cooling tower constructed on a reinforced concrete basin. The tower will have a wood structure; the wood will be coated by a fire retardant and a fire retardant PVC fill. The tower will be equipped with an automatic sprinkling system for fire protection.

Details of the Mechanical Draft Cooling Towers are:

Number of Cells	4
Manufacturer/Model	(Later)
Type	Cross-flow mechanical draft
Heat load, design	20 MW
Pumping head	(Later)
Fan motor power	100 hp
Flow	6700 gpm
Wet bulb, design	79°F

Inlet temperature, design	108°F
Outlet temperature, design	90°F
Fill type	Splash bar
GAI Specification	373-331
Equipment Number	373MCT001

2.1.2 Cooling Tower Circulating Water Pumps

The cooling tower circulating water pump details are:

Quantity	2
Type	Horizontal split case, single stage, double suction
Manufacturer/Model	(Later)
Head, design	90 ft.
Flow, design	3500 gpm
Speed	1780 gpm
Motor Power	(later)
GAI Specification	371-331
Equipment Number	373MPP001, 373MPP002

2.1.3 Automatic Water Strainer

The automatic water strainer details are:

Quantity	1
Type	Vertical, automatic backflush
Manufacturer/Model	(Later)
Pressure Drop	(Later)
Filter Size	250 micron (0.010 inches)
Flow Capacity, design	7000 gpm
Motor Power	(Later)

GAI Specification	373-332
Equipment Number	373MST001

2.1.4 Acid Treatment Package

The acid treatment package will include an acid storage tank, a positive displacement pump, and a controller and will be designed to supply acid to the Cooling Tower Water to control the pH. Details are listed below:

Quantity	1
Manufacturer/Model	(Later)
Tank Size	(Later)
Pump Capacity	(Later)
GAI Specification Number	(Later)
Equipment Number	373MAA002

2.1.5 Sodium Hypochloride Treatment Package

The sodium hypochloride treatment package will include a storage tank, a positive displacement pump, and a controller and will be designed to chlorinate the water of the Cooling Tower System to control algae, fungus, and other growths. Details are listed below:

Quantity	1
Manufacturer/Model	(Later)
Tank Size	(Later)
Pump Capacity	(Later)
GAI Specification Number	(Later)

2.2 INSTRUMENTS, CONTROLS, ALARMS AND PROTECTIVE DEVICES

The Cooling Tower System will be provided with sufficient pressure, temperature, level and flow measuring devices and alarms to ensure satisfactory system operation. Indicators for system status and performance evaluation will be located in the (Later) control room and at local panel (Later).

2.2.1 Instruments

a. Pressure Indicators:

Direct reading indicators will be provided at the following locations:

1. Discharge of cooling tower pumps.
2. Deleted
3. Deleted
4. Outlet of both demineralizer heat exchangers.

b. Pressure Transmitter:

A pressure transmitter will be located in the discharge header of the cooling tower pumps to the demineralized water heat exchangers. Indication will be provided in the (Later) control room.

c. Differential Pressure Indicator:

A differential type pressure gauge will be provided across the automatic strainer for local indication and alarm in the (Later) control room.

d. Pressure Switch:

A pressure switch will be provided in the discharge heater of the cooling tower pumps for the purpose of interlocking the pumps' start if the system pressure is not adequate and for alarm purposes.

e. Temperature Elements:

Temperature elements will be provided at the following locations to sense system temperatures:

1. Inlet to the cooling tower.
2. Discharge of the cooling tower basin.
3. Deleted
4. Deleted
5. Discharge of the demineralized water main heat exchanger.
6. Discharge of the demineralized water auxiliary heat exchanger.

f. Temperature Transmitters:

Temperature transmitters will be provided at the locations listed in item e. above and will provide indication local and (Later) control room. High and low alarms will also be provided for annunciation of a malfunction.

g. Level Switch:

A level switch will be provided in the cooling tower basin for a promissive to start the cooling tower pumps and to alarm at a low level in the basin.

h. Level Controller:

A level controller will be provided at the cooling tower basin to maintain an adequate supply of water in the basin. This controller will be used to modulate the make-up water as needed to maintain proper water inventory.

i. Flow Elements:

Flow elements will be provided at the following locations:

1. Discharge header of the cooling tower pumps.
2. Inlet to the instrument air compressor package.
3. Deleted
4. Deleted
5. Discharge of the demineralized water main heat exchanger.
6. Discharge of the demineralized water auxiliary heat exchanger.

j. Flow Transmitter:

Flow transmitters will be provided in the discharge header to provide for flow indication on the (Later) control room and to alarm at low water flow.

k. Flow Switches:

Indicating flow switches will be provided at the following locations for local readout and for low flow alarm:

1. Inlet to the instrument air compressor package.
2. Deleted
3. Deleted

l. Flow Indicators:

Local flow indication will be provided at the following locations:

1. Deleted

2. Deleted

3. Discharge of the demineralized water main heat exchanger.

4. Discharge of the demineralized water auxiliary heat exchanger.

m. Control Switches:

Control switches will be provided on the (Later) control room for the purpose of controlling the motor operated valves at the discharge of the demineralized water heat exchangers. The motor-operated valves will be used to isolate the heat exchangers and to balance the flow through these devices.

2.2.2 Alarms

An annunciator will be provided on the (Later) control panel in the (Later) control room to warn the operator of any malfunctions in the system.

3.0 OPERATION

3.1 STARTUP

During initial system startup, manual operation of the pump discharge valves will be required to prevent pump run out and water hammer. After the system is filled, no special preparation will be required because the system will be equipped for automatic startup. Whenever the system has not been operating for a prolonged period of time, the system may require extensive blowdown to obtain an acceptable system water chemistry before restarting. The system will be designed to operate with both pumps running. All manual and motor operated valves must be in the position as indicated on the referenced system flow diagram for normal operation.

3.2 NORMAL OPERATION

During normal operation no operator action will be necessary except for periodic system instrumentation observation.

During normal operation when the EBT Device is operating, the Cooling Tower will have a maximum design heat load on it. The Cooling Tower pumps will circulate cooling water to the demineralized water main heat exchanger; and instrument/service air compressor intercooler and aftercooler.

The automatic water strainer will be in operation whenever the system is operating. The strainer's backflush cleaning will be dependant on the pressure drop across the strainer and will clean itself automatically without interrupting the system service.

3.3 SHUTDOWN

During times when the EBT Device is not operating, the Cooling Tower System will still be in operation, and the Cooling Tower will have a reduced heat load on it. The pumps will circulate water to the demineralized water auxiliary heat exchanger to remove any heat load generated by equipment that still requires cooling; and to the instrument/service air compressor intercooler and aftercooler. Depending on the heat load, either both pumps could be operating at reduced capacity; one pump could be operating while the other is being maintenanced; or both pumps could be operating at full speed making use of the system's built-in bypass lines. The Demineralized Water and Instrument/Service Air System Descriptions provide the cooling requirements during the different modes of operation.

The automatic water strainer will work as usual during normal conditions.

4.0 SAFETY PRECAUTIONS

4.1 HAZARDS

Hazards existing in the Cooling Tower System are those normally associated with rotating equipment.

During periods when the cooling tower is not in operation, special attention must be given to fire protection since the structural wood will become dry and be more susceptible to fire.

4.2 PRECAUTIONS

During normal and shutdown operation all valves should be aligned properly. Idle equipment should be tested periodically. No demineralized water, or instrument/service air circuit should be in operation without Cooling Tower System operation. All pumps and control systems should be tested for 10 minutes each month.

All air should be removed from the system before startup to prevent water hammer.

4.3 HYDROSTATIC TEST

Hydrostatic testing should be performed after joint harnesses are properly installed and tightened in order to support the hydraulic thrust due to hydrostatic test pressure. Joint harnesses should be loosened, as noted on system piping diagrams, before backfill.

5.0 MAINTENANCE

Preventive maintenance for the Cooling Tower System equipment will consist of service recommended by the equipment manufacturers. Inspection of system piping will be satisfied by the use of a removable section of pipe to permit access and inspection.

GAI FLOW DIAGRAM 302-001

PRELIMINARY SYSTEM DESCRIPTION
INSTRUMENT/SERVICE AIR SYSTEM

PREPARED FOR
ELMO BUMPY TORUS
PROOF OF PRINCIPE - TEST FACILITY
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

Prepared By

Gilbert Associates, Inc.
P.O. Box 1498
Reading PA

TABLE OF CONTENTS

1.0 INTRODUCTION

This document presents a description of the Instrument/Service Air System for the Elmo Bumpy Torus Proof-of-Principle (EBT-P) Test Facility to be constructed in Oak Ridge, Tennessee, for the Department of Energy. It includes the design, functions, description, details of components, controls and instrumentation, operation, and maintenance. The system flow diagram is GAI drawing 374-302-001.

1.1 SYSTEM FUNCTION

The Instrument/Service Air System supplies oil-free air for instruments, valve operators, and controllers in the Demineralized Water System, Cryogenic System, and Vacuum System. The system also supplies lubricated shop-air in the Mechanical Equipment Building, the Cold Box Enclosure, the first and second levels of the Device Enclosure, and within the lower test support buildings' operations area.

1.2 DESIGN REQUIREMENTS

The Instrument/Service Air System supplies instrument and service air at 420s cfm and 100 psig to the Demineralized Water System, the Cryogenic System, the Vacuum System, and to the Mechanical Equipment Building, Cold Box Enclosure, the first and second levels of the Device Enclosure, and the lower test support buildings' operations area. The system also consists of one air compressor, dryer inlet filter, a refrigerant air dryer, dryer discharge filter, and a receiver tank.

The receiver tank is designed, fabricated, tested, and inspected in compliance with the requirements of the ASME Section VIII, "Boiler and Pressure Vessel Code for Unfired Pressure Vessels." All interconnecting piping and valves are designed, fabricated, tested, and inspected in compliance with the requirements of ANSI B31.1, "Power Piping."

1.3 SUMMARY DESCRIPTION

The Instrument/Service Air System for the EBT-P Facility will consist of one reciprocating air compressor, a refrigerant air dryer with inlet and outlet filters, an air receiver tank, and associated piping and valves.

The single air compressor and associated equipment will supply dry, oil-free air to the valve operators, controllers, and instrumentation in the Demineralized Water System, Vacuum System, and Cryogenic System. The compressor will also supply shop-air which needs to be lubricated with local air lubricators to the Mechanical Equipment Building, first and second levels of the Device Enclosure, the Cold Box Enclosure, and the lower level of the test support buildings' operations area to be used for pneumatic tools via shop quick disconnects.

The air compressor will be a reciprocating, electric motor-driven, oil-free, full-capacity compressor with an intercooler and aftercooler. The intercooler and aftercooler will receive cooling water from the Cooling Tower System at 90° F to lower the air temperature to 110° F. The air will be dried by a refrigerant electric motor-driven dryer with an inlet and outlet filter before entering the air receiver tank. The air receiver tank will automatically be maintained at 100 + 5 psig by pressure switches. Since the air compressor will produce air which is essentially oil-free when it is necessary, the air will be lubricated with inline air lubricators.

2.0 DETAILED DESCRIPTION

2.1 COMPONENTS

2.1.1 Air Compressor Package

There will be one full-capacity air compressor package. The package will consist of a closed-coupled, electric motor-driven, dual-stage, water-cooled, oil-free, reciprocating air compressor with an inlet and an emergency outlet silencer, intercooler, and aftercooler. Details are listed below.

Quantity	1
Manufacturer/Model	(Later)
Capacity	420 cfm
Discharge Pressure	120 psig
Motor Power	100 hp
Cooling Water Flow	(Later)
GAI Specification Number	374-331
Equipment Number	374MCP001

Also included in the air compressor package will be an air receiver tank equipped with a 0 to 200 psig pressure gauge, and a 150 psig, 420 cfm relief valve, and associated pressure switches. Details are listed below.

Quantity	1
Manufacturer	(Later)
Size	55 ft^3
Pressure, Working	150 psig
Operating Pressure	100 ± 5 psig
GAI Specification Number	374-331
Equipment Number	374MCR001

2.1.2 Air Dryer Package

The air dryer package consists of a single, full-capacity dryer and one inlet and outlet filter with details listed below.

Item	Air Dryer
Quantity	1
Manufacturer/Model	(Later)
Type	Refrigerant
Capacity	400s cfm
Dew Point @ 100 psig	35° F
Pressure, maximum	135 psig
Pressure, normal	115 psig
GAI Specification Number	374-332
Equipment Number	374MDR001

Item	Inlet Filter
Manufacturer/Model	(Later)
Type	(Later)
Pressure, design	125 psig
Capacity	420s cfm
GAI Specification Number	374-332
Equipment Number	374MFL002

Item	Outlet Filter
Manufacturer/Model	(Later)
Type	(Later)
Pressure, design	125 psig
Capacity	420scfm
Dust Size, minimum	10 microns
GAI Specification Number	374-332
Equipment Number	374MFL001

2.1.3 Air Lubricators

Quantity	(Later)
Manufacturer/Model	(Later)
Type	(Later)
Flow Capacity	(Later)
Size	(Later)
Equipment Numbers	(Later)

2.2 INSTRUMENTS, CONTROLS, ALARMS, AND PROTECTIVE DEVICES

The instrument air compressor will be operated with control switches on the (Later) control room panel and local control panel. A transfer switch located at the local panel will defeat all automatic signals and will initiate an alarm in the (Later) control room.

2.2.1 Instrument Air Control

During normal operation, the instrument air compressor will be designed to maintain proper air pressure. The compressor will be loaded and unloaded based on the system pressure. Since the loss of the instrument air system will result in the shutdown of the plant, all precautions should be exercised to ensure an uninterrupted supply of instrument air.

2.2.2 Protective Devices

The compressor will be tripped automatically upon a high discharge air temperature and a hi-hi discharge air pressure.

2.2.3 Instrumentation

Air dryer instrumentation controls will be supplied intregally with the air dryer. Abnormal operation with the air dryer controls will initiate an alarm on the (Later) control panel.

The Instrument Air System has the necessary instrumentation, controls, and alarms required for the safe, reliable operation of the system. Alarms will be provided on the (Later) control board.

a. Temperature Instrumentation:

1. High temperature interlock to trip the compressor.

2. High temperature alarm at the discharge of the compressor.

3. High temperature alarm with local indication downstream of the outlet filter.

4. Temperature indicator on the discharge of the air compressor.

b. Pressure Instrumentation:

1. Local pressure indicators will be provided at the receiver tank, upstream and downstream of the aftercoolers, dryer inlet and outlet, dryer filter and in the air heater of the instrument air supply.

2. A pressure switch on the air receiver tank will be used to interlock the loading and unloading of the air compressor and for low alarm function.

3. A local pressure transmitter downstream of the air receiver will be provided for pressure indication in the (Later) control panel.

3.0 OPERATION

3.1 STARTUP

The Instrument/Service Air System is normally in operation at all times. The air compressor is started automatically by a low pressure signal from the air receiver tank pressure switches.

3.2 NORMAL OPERATION

The Instrument/Service Air System will operate continuously. The single full-capacity air compressor is automatically tripped on or off by a signal from the pressure switches on the air receiver tank upon reaching the high or low pressure limits in the tank.

The constant discharge pressure control mode is affected by throttling the compressor suction valve to reduce compressor air flow. When the suction valve reaches the minimum allowable flow position, an atmospheric bypass valve is positioned to maintain required air demand.

3.3 SHUTDOWN

The system is normally left in service during plant shutdown. In case of maintenance to the system, the air compressor and air dryer is shut down by selecting the "off" mode in the manual switch.

4.0 SAFETY PRECAUTIONS

No special hazards are considered to exist in the system, except those normally existing with rotating equipment, machinery, and compressed air. Routine monitoring of conditions existing in the system should assure its safe and continuous operation.

5.0 MAINTENANCE

The condition of the pressure drops across the air dryer inlet and outlet filters should be checked periodically. Air lubricators oil reserves should be maintained at their suggested levels. Normal equipment maintenance, as suggested by the manufacturers, should be maintained.

EQUIPMENT DATA

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
PROOF OF PRINCIPLE FACILITY SYSTEM

GILBERT ASSOCIATES, INC. — COOLING WATER PURIFICATION SYSTEM

____
(BIDDER'S NAME)

i.	Filter element:		
	(1) Material of construction		______
	(2) Slot size		______
j.	Valve		______
k.	Piping		______
l.	Instrumentation		______
m.	Backwash water required	gpm	______
n.	Backwash water pressure	psi	______
o.	Backwash time required	min	______
p.	Air required	scmf/psi	______ / ______
q.	Operation time between backwash	h	______

DESIGN CRITERIA

GROUNDING AND LIGHTNING PROTECTION

ELMO BUMPY TORUS
PROOF-OF-PRINCIPLE TEST FACILITY

McDONNELL DOUGLAS ASTRONAUTICS COMPANY

1.0 GENERAL

The grounding and lightning protection systems for the EBT Facility were designed to provide safety to personnel and protection to the equipment. The system was designed to comply with the codes and standards set forth by the National Electrical Code, the National Fire Protection Association, and IEEE Standard 142. FAA report No. FAA-RD-75-215, "Grounding, Bonding, and Shielding Practices and Procedures for Electronic Equipments and Facilities, provided specific grounding and bonding recommendations which were considered in the design.

2.0 MAIN GROUND GRID DESIGN

The main ground grid establishes the electrical connection between the Facility and the body of the earth. The design objective is to obtain a low contact resistance between the grounding system and earth. A 1 ohm valve was used for calculation purposes to determine the minimum number of ground rods necessary to achieve this resistance. The calculation procedure was performed in accordance with FAA-RD-75-215 using the following information and materials:

1. Soil resistivity test values.
2. Ground Rods; copper clad steel, 5/8" x 10'.
3. Average ground rod spacing of 30'.
4. Ground conductor; 4/0 copper clad cable; approximately 6000' of conductor is needed.

According to calculations, a minimum of 90 ground rods are necessary to achieve the 1 ohm resistance. The actual number of rods to be used was approximated to be 146. Therefore, the 1 ohm resistance will be obtained.

All building steel columns, tanks, fence, and other metallic structures will be connected to the main ground grid. Also, the Facilities internal ground systems, both single-point and multiple point ground connections, will be connected to the grid. Figures 1 through 6 show the ground rod locations and interconnections for the Facility. The rods and cable will be completely buried except for a few concrete grounding wells (shown on the drawings as a square with a dot inside) for access. Conductor burial will be a minimum of 18 inches away from each building, pad, tank, etc., and 24 inches deep. The top of the ground rods must be at least 12 inches below the grade level.

3.0 EQUIPMENT GROUNDING (LOW FREQUENCY AND INSTRUMENTATION)

The purpose of the low-frequency and instrumentation grounding network (0-30k HZ) is to provide a single-point reference for low frequency signals, minimize power frequency noise levels in sensitive low frequency equipments, and provide for fault protection and static discharge of otherwise isolated networks.

Figures 7 and 8 show the approximate locations of the 2" x 12" x 1/4" copper ground bars for equipment grounding connections which are interconnected with 4/0 copper cable. Levels 1 and 2 are insulated radial systems joined together and connected to a single ground rod in the main ground grid. This point may also be the point of connection of the power system ground and the low voltage ground system.

The Test Center control room will have its grounding system located on or near the room walls. This system, which is connected to the system of Figure 8, will use 3/4" diameter x 0.060 wall copper tubing as the conductor, and must be isolated from all other ground systems. Interconnection with equipment will be made using plastic-coated 2/0 copper cable.

4.0 LOW VOLTAGE GROUND SYSTEM

The low voltage ground system is the protective ground for all lighting receptacles, low voltage control, etc. The system will provide a single-point reference which will be connected at the grounding point of the low frequency and instrumentation system and power system ground.

The low voltage ground system will be designed in accordance with the standards set forth in the National Electrical Code.

5.0 SIGNAL GROUNDING (HIGH FREQUENCY)

Due to the existence of high frequency equipment in the Facility (over 30 k HZ), a separate high frequency ground system is necessary. This system will control both conducted and radiated interference signals and will prevent or minimize coupling of high frequency noise to susceptible equipment.

This system includes establishing a ground grid beneath the test Facility as shown in Figure 2 and bonding the rods to the ground bars as shown in Figure 9. Also, a steel plate used for support of the upper floor, plus the rebar in the floor concrete will be electrically bonded together and bonded to the structural I-beams. The I-beams will then be connected to the main ground grid at various points. All other metal flooring, structures, high frequency equipment, cable trays, bus ducts, conduit, structural rebar, etc. will be bonded to either the support plate or the Facility structure.

6.0 SHIELDING AND BONDING

Shielding of the Facility is necessary to provide additional protection of personnel and equipment. It will be provided through the building itself, plus the steel structure, rebar, metal equipment and floor plates, if all parts (other than the concrete) are correctly bonded together and connected to the ground grid.

Proper bonding can be provided through various methods. However, welding is the most effective and will be used whenever possible to provide electrical continuity between the components of the Facility and the ground grid. Also, metal jumper straps will be used at I-beam joints, between the support plate and the I-beams (with the I-beams to be ground grid), and at any other joint between unlike metals or equipment to the ground system. Brazing will be used for permanently bonding copper and brass.

Soldered connections will not be used in the safety grounding network or in the lightning protection system.

7.0 LIGHTNING PROTECTION

To protect the Facility from lightning strikes, a system was designed to provide adequate lightning discharge through the grounding systems. Figures 10 through 13 show lightning rod locations and conductor paths for all required buildings and structures. Metal tanks do not neet lightning protection since they act as a conductor if properly grounded. Rods will be 12" copper or copper-clad steel, maximum 1/2" diameter and spaced approximately 20' apart. Rod interconnection conductor and down conductors will be No. 2 AWG stranded copper. Approximately 95 rods and 3000' of conductor will be needed.

The lightning protection system has been designed to provide a full zone of protection to the Facility. If any changes or additions are made to the EBT-P buildings, revisions will be necessary to the rod layout.

FIGURE 1

Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY ADMIN. BLDG. GROUNDING SYS.		CISID		PAGE OF PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G.S. Koenig				
	DATE 4/24/81				

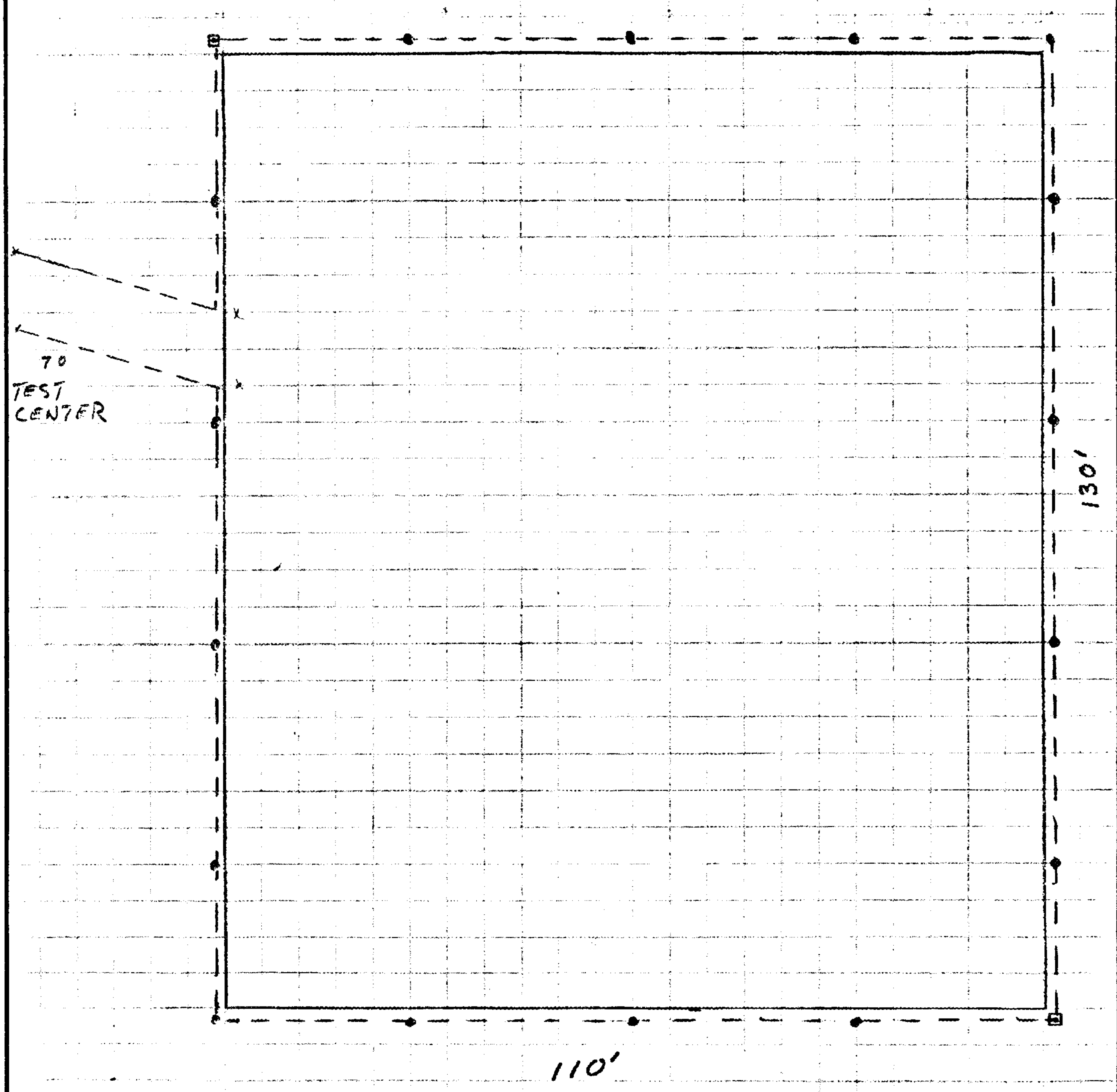
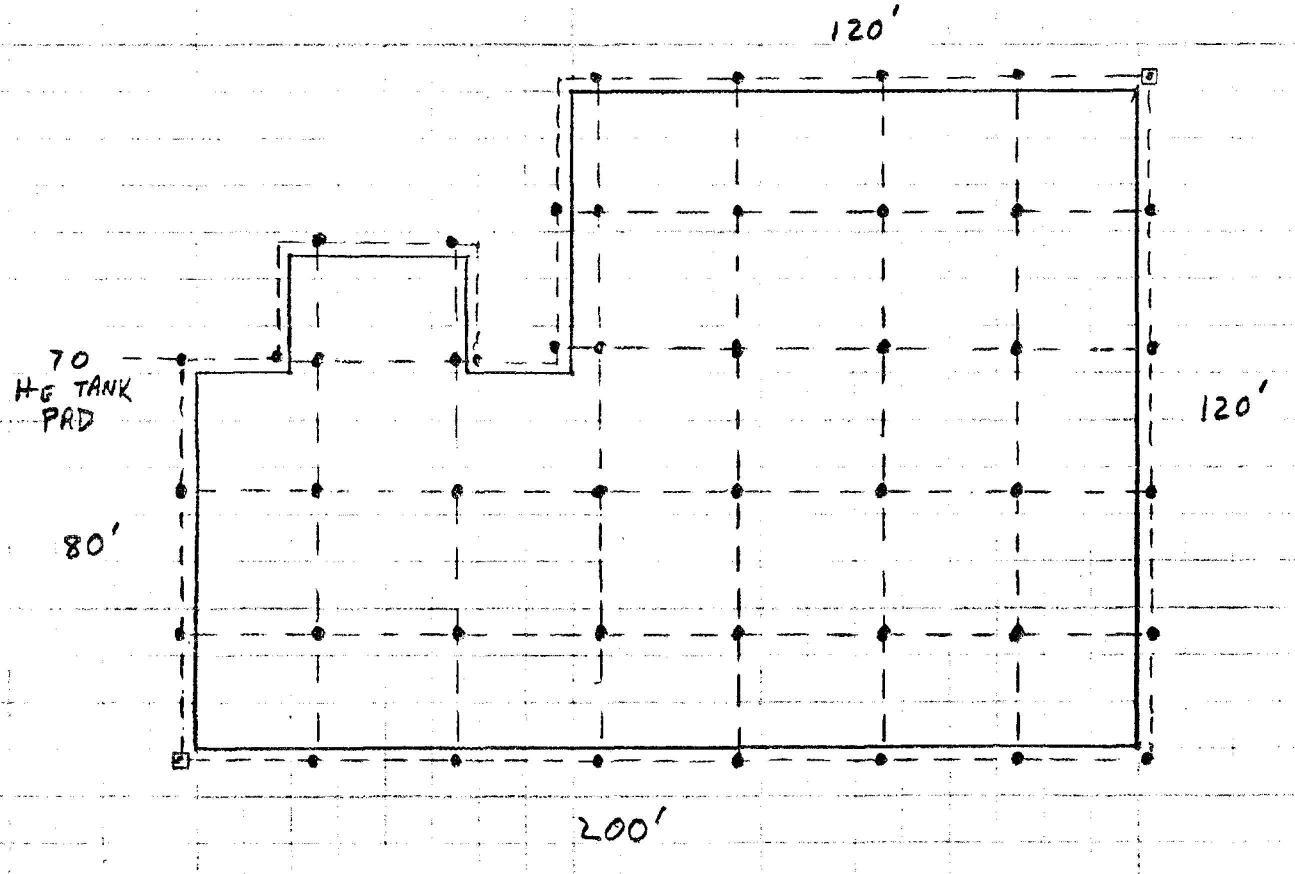


FIGURE 2

Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY TEST CENTER GROUND GRID *			CISID	PAGE ___ OF ___ PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G.S. Koenig				
	DATE 4/24/81				

* ALSO REPRESENTS HIGH FREQUENCY GROUND GRID

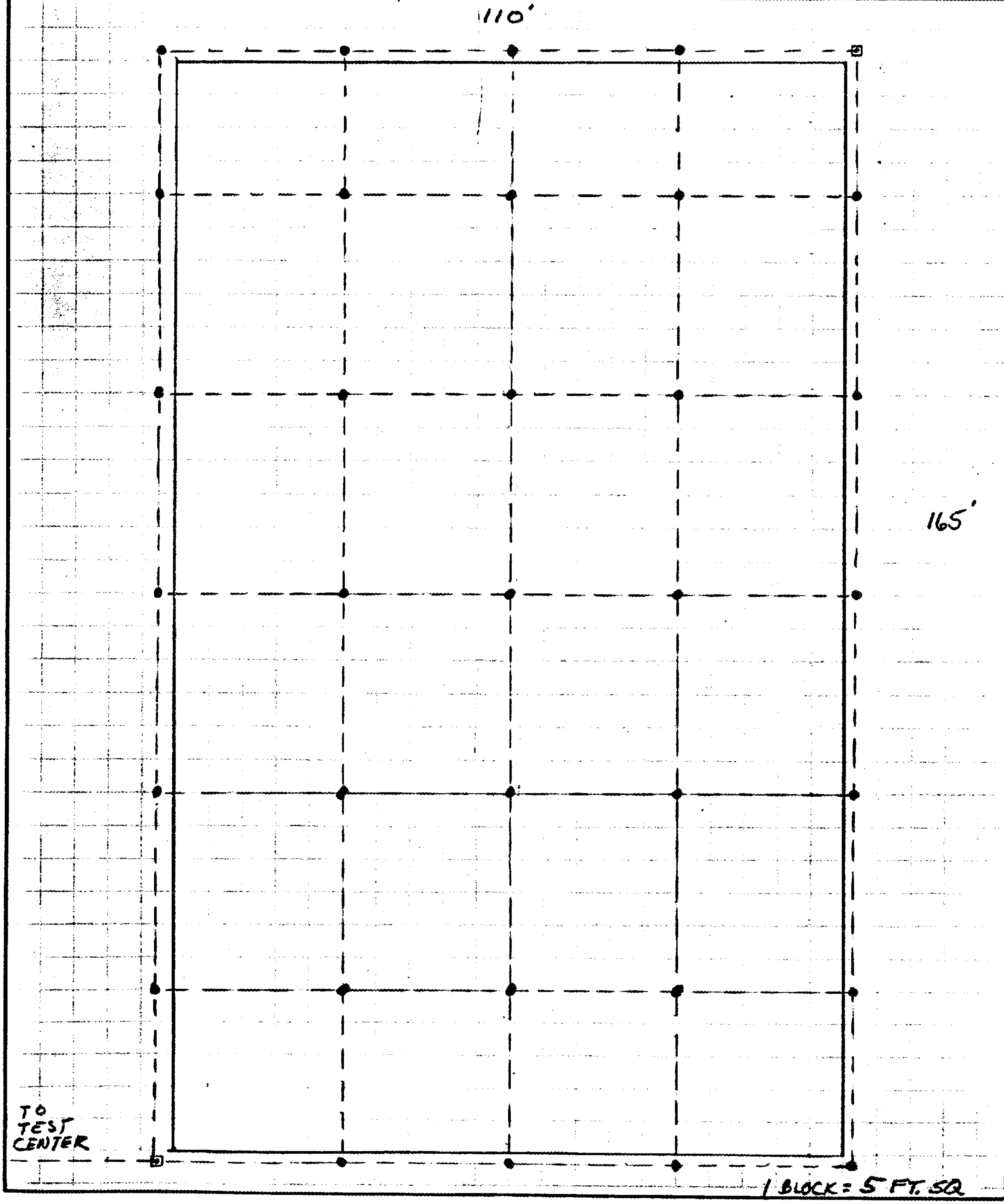


1 BLOCK = 10 FT. SQ.

GAI 446 11-78

FIGURE 3

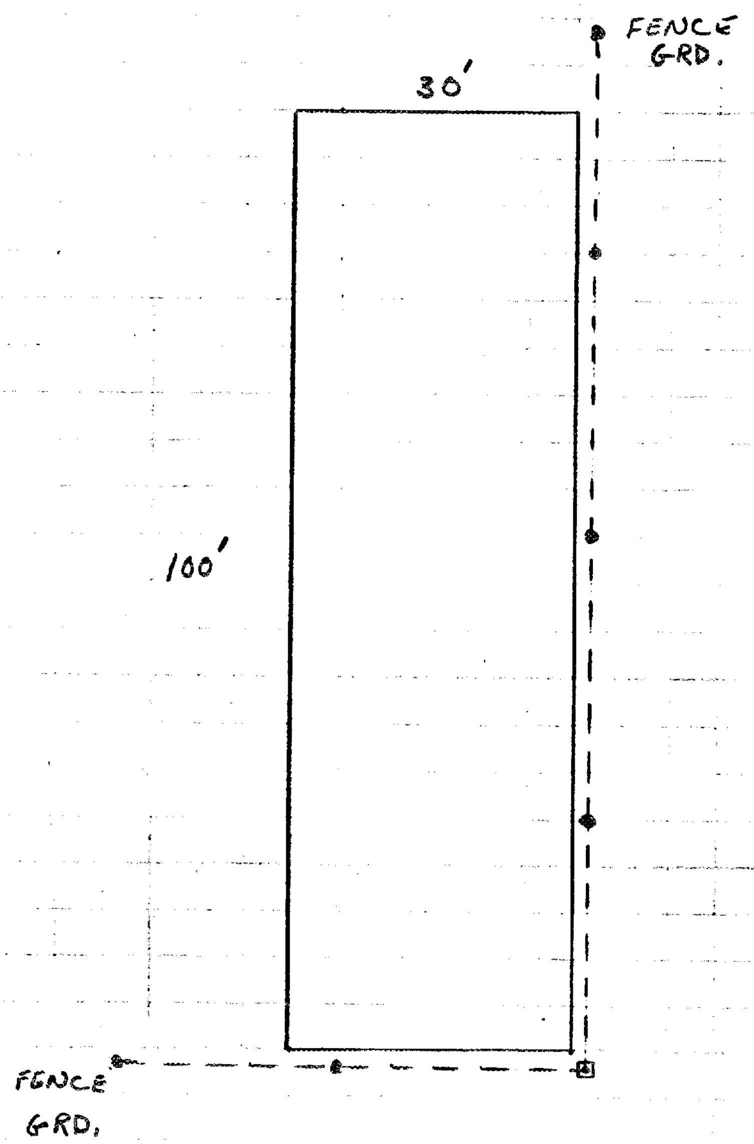
Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY SUBSTATION GROUND GRID		CISID		PAGE — OF — PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G. S. Koenig				
	DATE 4/24/81				



GAI 446 11-78

FIGURE 4

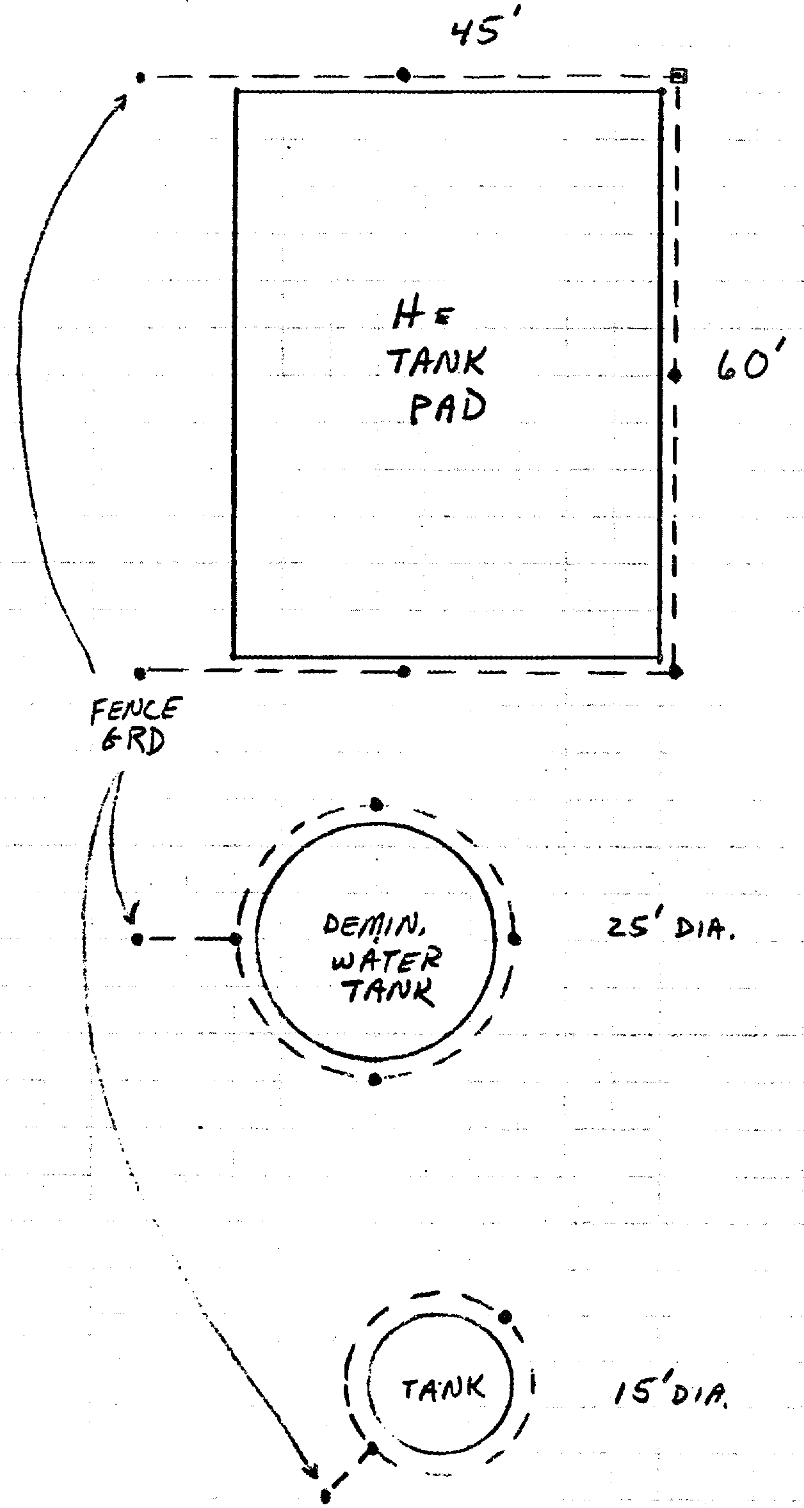
Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY MECH. COOLING TOWER GROUNDING			CISID		PAGE OF PAGES
	REV.	0	1	2	3	
	MICROFILMED					
	ORIGINATOR	G.S. Koenig				
	DATE	4/27/81				



1 BLOCK = 5 FT. SQ.

FIGURE 5

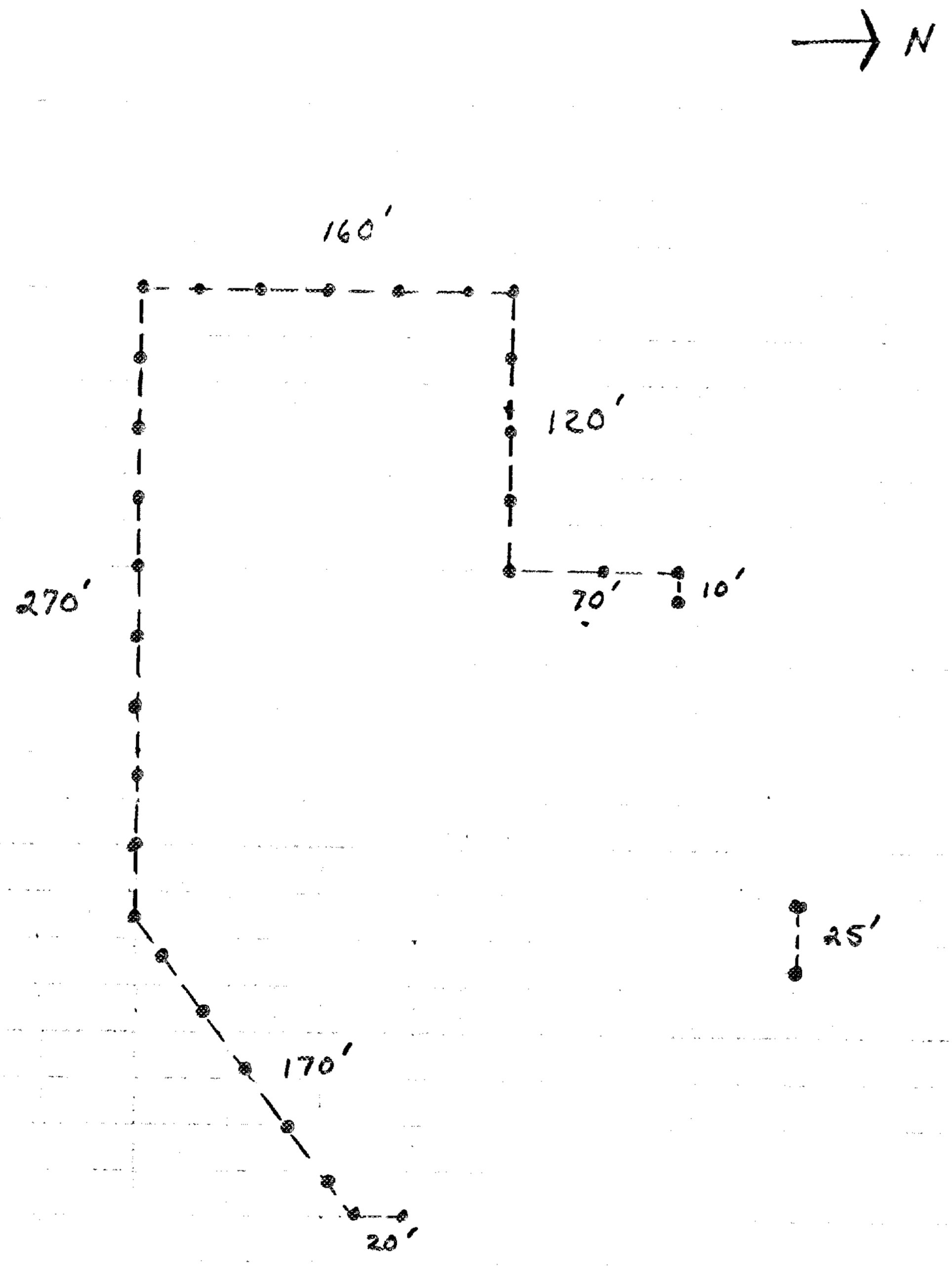
Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY PAD + TANK GROUNDING			CISID	PAGE
	REV. 0	1	2	3	OF
	MICROFILMED				PAGES
	ORIGINATOR J. S. Klein				
	DATE 4/27/81				



1 BLOCK = 5 FT. SQ.

FIGURE 6

Gilbert Associates, Inc. Reading, Pennsylvania	SUBJECT EBT FACILITY FENCE GROUNDING			CISID	PAGE OF PAGES
ANALYSIS/CALCULATION	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G.S Koenig				
	DATE 4/27/81				



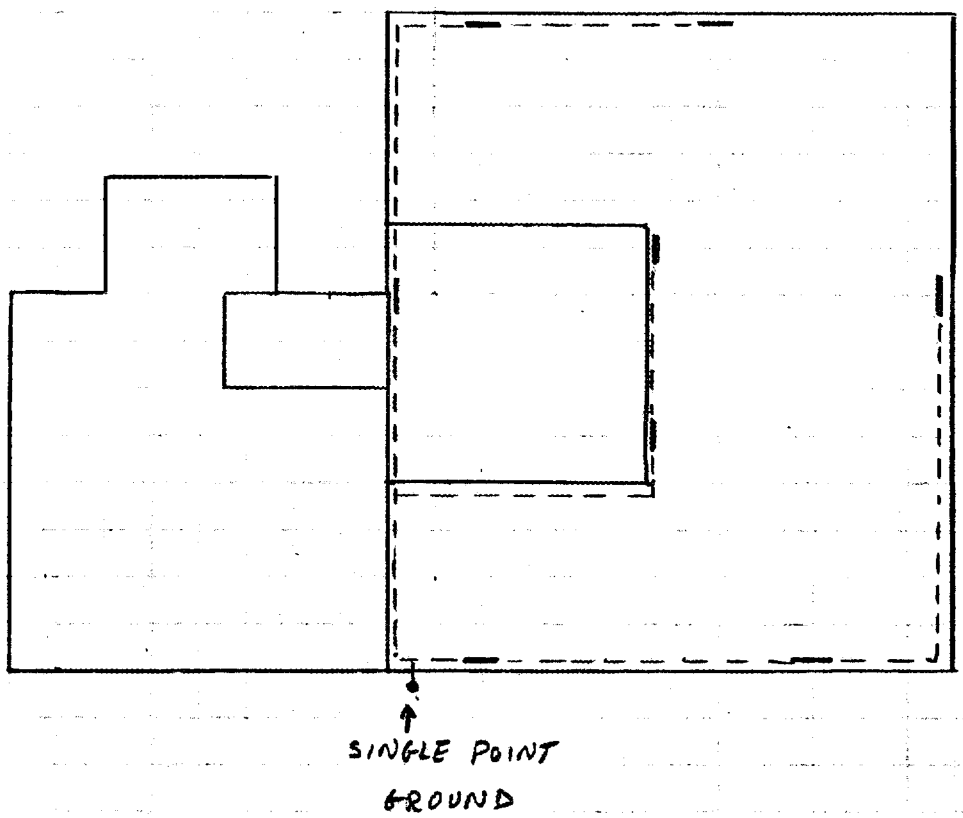
NOTE: GROUND GRID SHALL EXTEND NOT LESS THAN 3 FT. OUTSIDE FENCE.

1 BLOCK = 30 FT. SQ.

GAI 446 11-78

FIGURE 7

Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY - LEVEL 1 LOW FREQ. + INST. GROUND BARS			CISID	PAGE OF PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G. S. Koenig				
	DATE 4/27/81				



1 BLOCK = 10 FT. SQ.

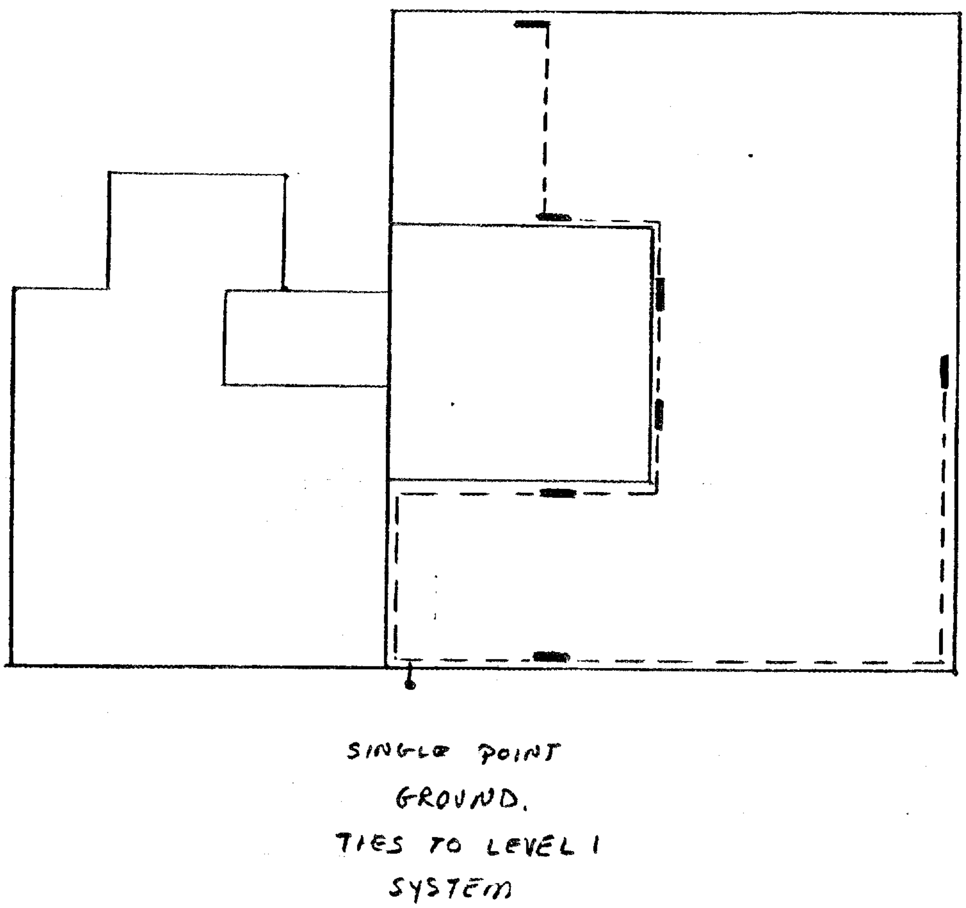
GAI 446 11-78

FIGURE 8

Gilbert Associates, Inc.
Reading, Pennsylvania

ANALYSIS/CALCULATION

SUBJECT EBT FACILITY - LEVEL 2 LOW FREQ. + INST. GROUND BARS			CISID		PAGE ___ OF ___ PAGES
REV. 0	1	2	3		
MICROFILMED					
ORIGINATOR G. S. Koenig					
DATE 4/27/81					

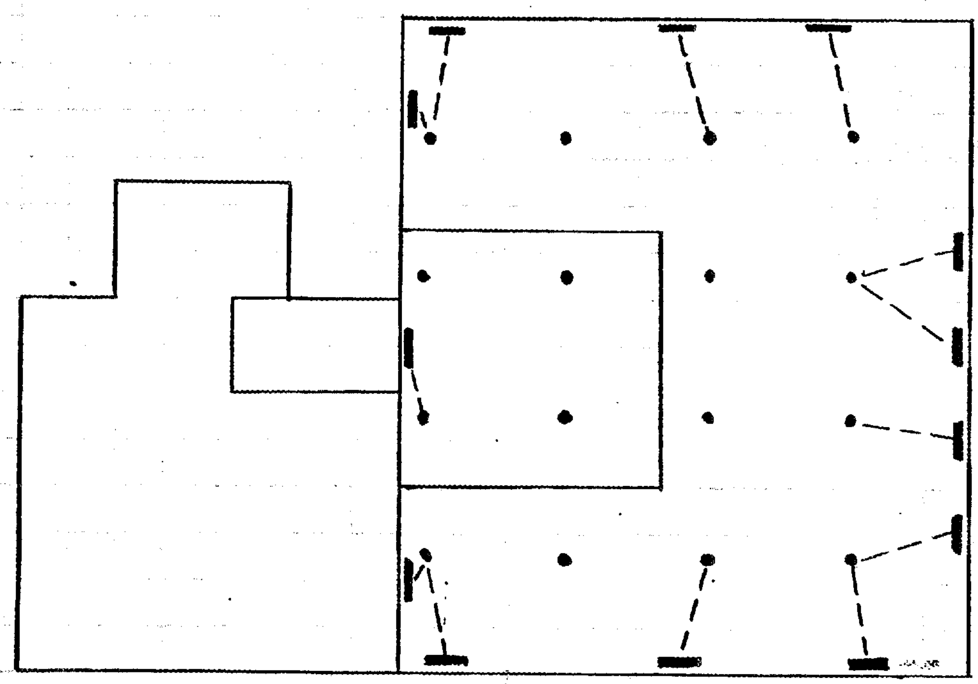


1 BLOCK = 10 FT. SQ.

GAI 446 11-78

FIGURE 9

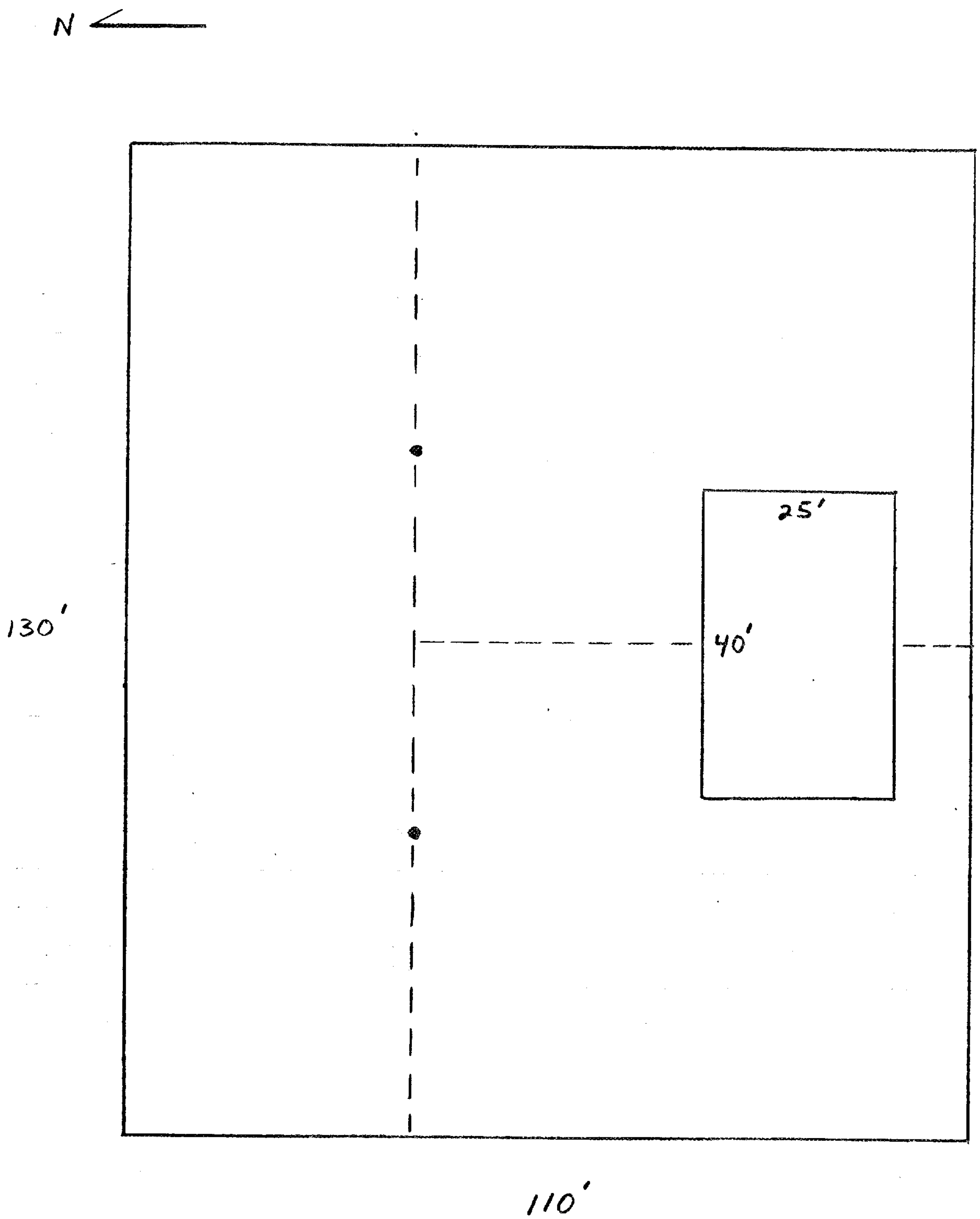
Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY - LEVEL 1 HIGH FREQ. EQUIP. PLATE GROUND		CISID		PAGE OF PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G. S. Koenig				
	DATE 4/27/81				



1 BLOCK = 10 FT. SQ.

FIGURE 10

Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY - LIGHTNING ROD LOCATIONS - ADMIN. BLDG. ROOF			CISID *	PAGE — OF — PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G.S. Koenig				
	DATE 4/27/81				



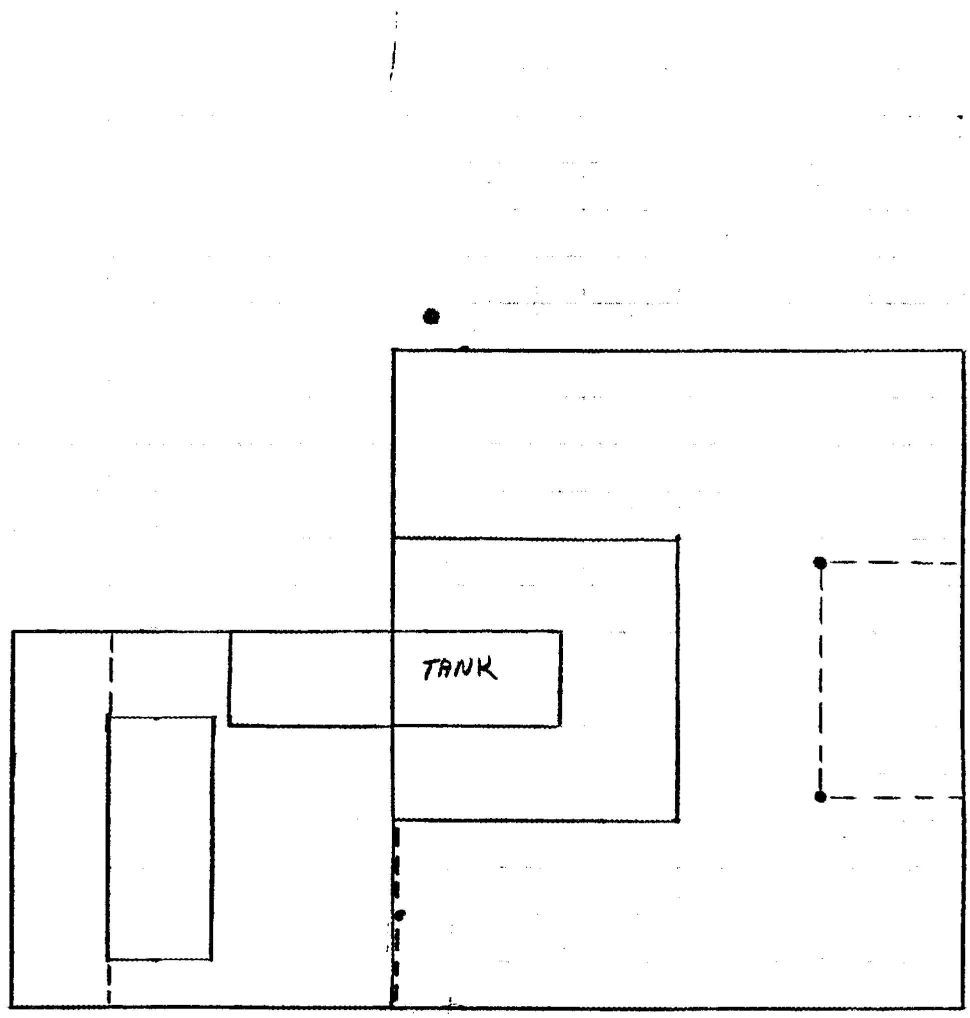
* BALANCE OF ROD LOCATIONS ON FIGURE 12

1 BLOCK = 5 FT. SQ.

GAI 446 11-78

FIGURE 11

Gilbert Associates, Inc. Reading, Pennsylvania ANALYSIS/CALCULATION	SUBJECT EBT FACILITY - LIGHTNING ROD + COND. LOCATIONS - TEST CENTER			CISID *	PAGE ___ OF ___ PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR G.S. Koenig				
	DATE 4/28/81				



* BALANCE OF ROD LOCATIONS ON FIGURE 13

1 BLOCK = 10 FT. SQ

DEVICE ENCLOSURE BUILDING

The Device Enclosure Building will be a two-level concrete structure, having interior clear plan dimensions of 50--0" x 52'-6". It is intended to maintain the level of radiation in the adjacent areas to 0.25 mR/Hr. The structure will be founded on sixteen (16) 4 foot 6-inch diameter drilled concrete caissons extending approximately 20 feet onto rock. A thick concrete base slab will be provided to distribute the loads of the equipment floor and the nine device support columns to the caissons.

The enclosure walls will be 8 foot, normal aggregate concrete extending to a level 39 feet above the quipment floor. The roof of the structure will be 5 feet thick normal aggregate concrete. It will be designed to allow casting in two lifts to minimize the load requirements for the supporting falsework.

Floor-to-floor height, between operating floor and equipment floor is fifteen feet (15'), with 24 feet required between the operating floor and the soffit of the concrete roof.

Personnel access to the Device Enclosure will be through labyrinths at opposite corners of each level, i.e. equipment and operating. Radiation absorption doors will be provided at the labyrinth exits.

The operating floor will consist of an eight inch (8") thick concrete slab, supported by the walls and the nine device support columns. The slab will be reinforced with stainless steel reinforcing to avoid interference with the device magnetic field. A 7 foot diameter opening is provided in the center of the slab for air circulation and equipment access.

1. STRUCTURAL REQUIREMENTS

(Descriptions of the building sizes and general materials of construction are contained in the Architectural Criteria.)

A. Codes, Standards and Regulations

1. Standard Building Code - 1978 Edition.

2. American National Standards Institute (ANSI) 58.1-1972 - Earthquake Loads only.

B. Design Basis

1. Loads

Dead Load: (D)

Weight of all permanent construction such as floors, roofs, permanent partitions, stairways, walls, and fixed equipment.

Live Load: (L)

a. Device Enclosure Building:

1. Concrete Grade Level Floor - 250 psf (as for rest of Test Building).

2. Second Floor - 200 psf + weight of applicable equipment.

3. Roof - 50 psf minimum (from Procurement Specification).

Wind Load: (W)

a. Basic wind speed = 100 mph (100-year mean recurrence interval) (from ANSI A 58.1-1972). This wind speed results in a pressure of q_f = 26 psf for ordinary buildings, and q_p = 38 psf for parts and portions of buildings at an elevation of 30 feet or less.

Earthquake Loads: (E)

a. Earthquake loads will be obtained by using Seismic Zone 2 and in accordance with procedures described in ANSI A 58.1-1972.

b. Earthquake loads will be applied in all three directions nonconcurrently; E-W, or N-S, or Vertical.

c. Earthquake loads will be applied to DL and permanent or long time live loads.

Snow Loads: (S)

a. Snow loads will be taken from SBC.

Temperature Loads: (T)

a. This is only a concern in the Device Enclosure.

Max. temp. = 104° F (During magnet quench only)

Normal operating temp. = $72 \pm 6^{\circ}$F(from Procurement Specification)

2. Load Combinations

a. Concrete (ACI 318-77)

U = 1.4D + 1.7L

U = 0.7S (1.4D + 1.7L + 1.7W)

U = 0.9D + 1.3W

U = 0.7S [1.4D + 1.7L + 1.7 (1.1E)]

U = 0.9D + 1.3 (1.1E)

U = 0.7S (1.4D + 1.4T + 1.7L)

U = 1.4 (D + T)

U = required strength

3. Structural Materials

a. Anchor Bolts - A 36

b. Concrete

1. Normal weight = 3000 psi @ 28 days

c. Reinforcement - Grade 60 per ASTM A 615 for walls, roof, and foundations; non-magnetic stainless steel equivalent of Grade 60 for operating floor slab.

GAI Fluid System Diagram

DELETED PER PDC 010 AND
REPLACED BY REFRIGERATED
AIR CONDITIONERS.

PRELIMINARY
SYSTEM DESIGN DESCRIPTION
O-SD-770

DEVICE UTILITIES HVAC

PREPARED FOR

ELMO BUMPY TORUS
PROOF OF PRINCIPLE-TEST FACILITY
McDONNELL DOUGLAS ASTRONAUTICS COMPANY

Prepared By:

Gilbert Associates, Inc.
P.O. Box 1498
Reading, Pennsylvania

System Designation: D-HVAC

Initial Issue 5/26/1981

TABLE OF CONTENTS

1.0 INTRODUCTION

This document presents a description of the Device Utilities Heating, Ventilation and Air Conditioning (D-HVAC) System for the Elmo Bumpy Torus Project. This description includes the system function, criteria requirements, details of instruments and controls, modes of operation, safety precautions, and maintenance requirements. The system is shown on GAI Fluid System Diagrams (Later).

1.1 SYSTEM FUNCTION

The D-HVAC system maintains an atmosphere suitable for the Device Utilities and its supporting equipment/instruments and is conducive to intermittent personnel occupancy in the following areas:

Torus Area
Test Support Area
Mechanical Equipment Area

1.2 CRITERIA REQUIREMENTS

The codes and standards to which this system and its components comply, general requirements, and considerations imposed by interface relationships with other systems and the environmental conditions required are as follows:

a. System Design Criteria

1. The system air flow rate is designed for the cooling load from the Device and various supporting equipment, instrument, and switchgear equipment used under Device operating conditions (ie. - when the "Device" is starting, operating, or cooling off) to maintain the temperature of subject areas within the design limits. The design parameters are:

(a) Outside Design Temperature

Summer	93°F (34°C) DB 79°F (26°C) WB
Winter	7°F (-13.9°C) DB

(b) Inside Design Temperatures*+

(1) Device Enclosure Building

DB (Normal Operating Condition)	$72 + 6^{o}$F
DB (During Magnet Quench)	104°F (40°C)
Relative Humidity (non-controlled)	50%

(2) Mechanical Equipment Building

Summer DB	78°F (25.6°C)
WB (not controlled)	64°F (18°C)
Winter DB	72°F (22.2°C)

(3) Test Support Area

Summer DB	78°F (25.6°C)
WB (not controlled)	64°F (18°C)
Winter DB	72°F (22.2°C)

*All design temperatures have a margin of ± 2°F unless otherwise specified.

+All design temperatures are given for plant conditions with the Device energized or cooling-off.

(c) The Device is capable of steady-state continuous operation for 16-hours in a 24-hour period. (Reference-Baseline Design Data Book, Section 2.1.2.1.1).

(d) Life expectancy is minimum 10 years at 4000 hrs/yr under EBT-P operating conditions (Reference-Baseline Design Data Book Section, 7.2.1.1).

(e) Ventilation

General — 5 CFM/Person Maximum

(f) Noise Levels

(1) 84 dbA in Operating Areas
(2) 55 dbA in Other Areas

(g) Normal Operating Pressure — Positive

2. General Criteria

(a) Federal Energy Efficiency Guidelines

(b) McDonnell Douglas Procurement Specification No. 70P374003 for EBT-P Facilities

b. Codes and Standards

1. General HVAC Design

(a) American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

(1) Guide and Data Book

(2) 36-72, "Standard for Measurement of Sound Power-Radiated from Heating, Regfrigerating and Air Conditioning Equipment."

(b) Carrier Corporation - Carrier System Design

(c) American Society for Testing and Materials (ASTM)

(d) Air Moving and Conditioning Association (AMCA)

300-67, "Test Code for Sound Rating Air Moving Devices"

(e) USAF Regulation 161-35, "Hazardous Noise Exposure"

(f) Occupational Safety and Health Act (OSHA)

(g) U.S. Department of Energy (DOE) ERDA Manual, Chapter 0550, Occupational Safety Standards ERDA Manual, Appendix 6301, General Design Criteria.

2. Electrical - General

(a) National Electrical Manufacturers Association (NEMA); Standard 117-1969 - "Preferred Voltage Ratings for A-C Systems and Equipment"

(b) National Fire Protection Association (NFPA) Standard NFPA 70 - "National Electrical Code"

3. Air Handling Units

(a) AMCA

(1) Standard 210-67, "Test Code for Air Moving Devices."

(2) Publication 99-1972, "Standards Handbook."

(b) American National Standards Institute (ANSI)

(1) Standard E16.5 - "Steel Pipe Flanges and Flanged Fittings"

(2) Standard E36.10 - "Wrought-Steel and Wrought-Iron Pipe"

(c) American Refrigeration Institute (ARI)

(1) Standard 430-66 - "Standard for Central Station Air Handling Units"

(2) Standard 410-72 - "Forced Circulation Air Cooling and Air Heating Coils"

(d) American Iron and Steel Institute (AISI), "Specification for the Design of Cold-Formed Steel Structural Members," 1968 Parts II, IV and V.

(e) ASHRAE

(1) 33-64, "Standard Method of Testing for Rating Forced-Circulation Air Cooling and Air Heating Coils."

(2) 52-68, "Standard Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter."

(f) American Society of Testing Materials (ASTM)

(g) American Welding Society (AWS) D1.1-72, "Structural Welding Code." Revision 1-73.

(h) American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

(i) Underwriters' Laboratories, Inc. (UL) 900-1965, "Standard for Air Filter Units."

4. Single Package Air Conditioning Units

(a) American National Standards Institute (ANSI)

(1) Standard E16.5 - "Steel Pipe Flanges and Flanged Fittings"

(2) Standard E36.10 - "Wrought-Steel and Wrought-Iron Pipe"

(b) AMCA Standard 210-67.

(c) NEMA-MGI-1972, Standards for Motors and Generators.

(d) ASHRAE Standard 15-70. (ANSI Safety Code for Mechanical Refrigeration, B9.1.)

(e) GAI Specification (Later), "Fractional HP and Larger Electric Motors to be Supplied with Driven Equipment."

5. Fans

(a) AMCA 99 - "Standards Handbook" (1967)

(b) AMCA 201 - "Fans and Systems"

(c) AMCA 202 - "Trouble Shooting"

(d) AMCA 210 - "Test Code for Air Moving Devices"

(e) AMCA AS401 - "Fans, Standard Classification for Spark Resistant Construction"

(f) AMCA AS2404 - "Fans, Arrangements of Drive"

(g) AMCA AS2406 - "Fans, Designation of Direction of Rotation and Discharge"

(h) AMCA AS2407 - "Fans, Motor Position, Belt or Chain Drive"

(i) AMCA AS2410 - "Arrangement of Drive for Tubular Fans"

(j) UL 507-1969 - "Standard for Safety for Electric Fans"

6. Ductwork and Accessories

(a) ASTM

(b) AWS D1.1-72, "Structural Welding Code," with Revision 1-1973.

(c) NFPA Bulletin 90A-1973, "Air Conditioning and Ventilating Systems."

(d) Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

(1) Low Velocity - Duct Construction Standards - 1969.

(2) Manual for the Balancing and Adjustment of Air Distribution Systems, 1967.

(e) Underwriters' Laboratories, (UL)

(1) 555-1973 - "Standards for Safety for Fire Dampers."

(2) 181-1967 - "Standard for Safety for Air Ducts."

(f) National Bureau of Standards (NBS) R207-60, "Pipes, Ducts and Fittings for Warm Air Heating and Air Conditioning Systems."

(g) AMCA 500 - "Interim Test Method for Dampers, Louvers, and Shutters."

7. Instruments and Controls

Instrument Society of American Standards (ISA)

c. <u>System Interfaces</u>

The D-HVAC System will interface with the following systems:

1. Chilled Water Generating and Distributing System.
2. Electrical Distribution System.
3. Instrument Air System.
4. Drainage System.

1.3 SUMMARY DESCRIPTION OF SYSTEM

Air handling units centrally located in different areas will continuously circulate conditioned air through the air conditioned areas specified in Item 1.1 to maintain the design ambient conditions.

The Torus Area AHU's function is a circulating mode only (i.e.; they draw in warm return air from the ceiling space of the Torus Area, filter and cool it, and then supply it back to the lower elevations of the Torus Area thru the duct distribution system).

The Conditioned Air Supply for both the Mechanical Equipment Area and the Test Support Area will be provided through circulating AHU's similar to the Torus Area AHU's. However, each of the Mechanical Equipment Area AHU's and Test Support Area AHU's will be equipped with an economizer control system that will allow using outside air for cooling whenever ambient temperatures permit.

Relief dampers will be provided in centrally selected locations to allow the excess air (excess air is the amount of air replaced by outside air brought into the building less the amount exhausted by various exhaust fans) to escape the building. Modulation of the dampers will be controlled from a centrally located ΔP sensor to maintain a slightly positive pressure in the Buildings.

Air blenders will be located upstream from the VAV-AHU's and the Mechanical Equipment Area AHU to assure proper mixture of outside air with the return air. This will avoid stratification or freezing outside air, thus protecting the chilled water coils from freezing.

2.0 DETAILED DESCRIPTION OF SYSTEM

2.1 COMPONENTS

2.1.1 Air Handling Units

Each air handling unit will consist of Throw Away (T/A) type filters, chilled water cooling coils, and a fan section. Mechanical Equipment Area AHU's and the Test Support Area AHU's will also include control dampers to control the return air/outside air mixture for the economizer mode of operation.

The AHU parameters are listed on the following page.

Air Handling Units Design and Operating Parameters

Tag. No.	502MAH012 thru 015	502MAH002 thru 005	503MAH007
Location	Torus Area	Test Support Area	Mechanical Equipment Area
Air Flow, cfm (cmh)	8,330 (14,165)	20,500 (34,917)	36,866 (62,673)
External ΔP - in. WG (mm. Aqua)	3 (7.62)	4 (10.16)	4 (10.16)
Fan Motor H.P.	Later	Later	Later
Electrical Characteristics	Later	Later	Later
Cooling Capacity, MBH (Kcal/hr)	250 (63 x 10^3)	312 (78,629)	800
Coil Face Velocity, fpm (m/min.)	500 (23.6)	500 (23.6)	500 (23.6)
Maximum Entrance Water Temp, °F (°C)	45 (7.2)	45 (7.2)	45 (7.2)
Chilled Water Flow, gpm (L/min)	50 (190)	62.4 (236.2)	160 (605)
Water Side ΔP, ft. (m)	Later	Later	Later
Air Filters Type	Low Velocity T/A	Low Velocity T/A	Low Velocity T/A

2.1.2 Exhaust Fans

The Exhaust Fans details are: (LATER)

Tag No.
Quantity
Location
Fan Type
Capacity-cfm (cmh)
External Pressure Drop
in. WG (mm. Ag.)
Fan Motor Horse Power
Type of Drive

2.2 INSTRUMENTS, CONTROLS, ALARMS, AND PROTECTIVE DEVICES

2.2.1 Air Handling Unit (AHU) Control

Each AHU will be provided with manual control by means of a control switch located on the (Later) Board in the Control Room. A transfer switch for each fan located on the local Control panel (Later) may be used to select manual control from these panels.

Each fan will be provided with indicating lights on the (Later) Board in the Control Room and on the local panels. These lights will indicate on and off modes.

The Torus Area AHU fans will be interlocked with the operation of the Device. Whenever the Device is in operation, the fans will automatically start and continue to run as long as the Device is energized. Space temperature controllers will modulate the three-way chilled water control valves. When the Device is de-energized, the fans will continue to run, maintaining the desired space temperature. Once the proper space temperature is attained, the fans will stop and be interlocked such that they cannot restart unless the Device is energized.

Each of the remaining AHU's fans unit will be energized by demand from a space thermostat and will continue to operate until manually de-energized. Each AHU will be equipped with chilled water control valves which will be energized when air flow is proven in the discharge duct of the AHU. Each valve will modulate the chilled water flow through the AHU coil to satisfy the space thermostat.

The roughing filter bank of each unit has a local differential pressure indicator. The startup crew will red line the pressure gage to indicate (high) final pressure drop across each filter bank.

Each AHU will control the leaving air temperature to maintain the design space temperature by modulating the chilled water flow rate through the chilled water cooling coils. The chilled water will by-pass the coil via three-way valves. On loss of control air, all chilled water will flow through the coil.

2.2.2 Damper Control

A pneumatic outside air intake damper (Later) and return air damper will be provided for each of the VAV AHU's and for the Mechanical Equipment Area AHU. Both dampers modulate during the "economizer" mode of operation whenever the outdoor temperature drops below 55° F (12.8° C), allowing outside cool air to be used for cooling. A temperature element located in the air condition space will control both dampers to maintain the design space temperature. Switches will provide indication of damper position ("open/closed") on the (Later) Board in the Control Room. The outside air dampers will automatically close on a loss of control air supply or power and the return air damper will open fully. If outside air temperature is above 55° F (12.8° C), the outside air dampers will close fully. Indicating lights will be provided on the (Later) control panel in the control room to indicate the status (open/close) of the dampers.

2.2.3 Alarms

A flow switch (Later) in each unit discharge duct will alarm the Control Room (Later) Board and will activate an amber light on same if the air flow falls below a preset value while the associated fan is in operation.

A smoke detector located in each unit discharge duct (Later) and in each return air duct (Later) will alarm the Control Room (Later) Board if smoke is present. Trouble alarms will be located on (Later) with a common alarm in the control room.

A temperature element (Later) located in each unit discharge duct will alarm the Control Room via the multipoint scanner (Later) if the temperature exceeds a preset value.

If any air handling unit control switch on the (Later) Board is in the "pullout" position, the (Later) Board will be alarmed.

Local temperature indicators will be provided inlet to each of the fans.

3.0 MODES OF OPERATION

3.1 STARTUP

Before initially starting this system check the following points:

a. Check all instrumentation for proper calibration and function.

b. Install clean filters.

c. Check all fans for proper rotation, design air flow rate, and motor loading.

d. Check all dampers for proper position.

e. Check and lubricate all parts which require lubrication.

After initial check up, the system is started by switching on each air handling unit. The air handling unit which is energized causes the respective associated dampers controls to also be energized.

3.2 NORMAL OPERATION

Under normal conditions, the system operates as described in Section 1.3.

3.3 SHUTDOWN

Any of the air handling units can be de-energized and its respective associated dampers and controls de-energized by turning its switch 'off' from the Control Room or locally.

3.4 SPECIAL OR INFREQUENT OPERATION

This system operates in conjunction with the Device Utilities.

3.5 EMERGENCY

There are no emergencies associated with this system.

4.0 SAFETY PRECAUTIONS

4.1 HAZARDS

The Torus Area AHU's will not be accessible during operation due to high radiation levels from the energized device.

4.2 PRECAUTIONS

Outside air intake dampers should be checked frequently for freedom of movement.

5.0 MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

a. The pressure drop across each filter should be checked periodically so that the filters are replaced before the pressure drop becomes excessive resulting in reduced air flow.

b. Chilled water, steam, and condensing water pipes serving this system should be checked periodically for any leaks.

c. For air handling units preventive maintenance and functional performance, refer to manufacturer's literature.

d. Check fans and motor bearings for vibration.

e. Check dampers for freedom of movement.

f. Check for worn out or loose bolts.

5.2 SPECIAL DESIGN CONSIDERATION

The AHU's economizer mode of operation, and the night-set-back settings are designed to enhance the energy conservation of this system.

5.0 PENDING DESIGN CRITERIA CHANGES

There are a number of pending Device Utility design criteria changes pending. The cost and schedule impact of each of these changes is currently being assessed by GAI. When this data is available, PDC's will be submitted to ORNL for approval. It is planned that these proposed changes will be dispositioned prior to the start of the Device Utility detail design effort. This start date is scheduled for 3 August 1981.

The pending Device Utility design criteria revisions are:

1. Revise device enclosure construction from abytes to normal aggregate concrete. (PDC 005)
2. Increase inside ceiling elevation from 35 feet to 39 feet. (PDC 005)
3. Install bridge crane within device enclosure. (PDC 005)
4. Provide trench in device enclosure grade level floor for gyrotron mounts. (PDC 005)
5. Provide "picture window" diagnostic penetrations on east, south, and west walls. (PDC 005)
6. Provide penetrations in device enclosure second level floor for diagnostics and related shielding.
8. Route DM water to diagnostic laboratories.
9. Route DM water outdoors to ECRH power crowbar and regulator assemblies.
10. Reduce cooling tower capacity from 30 MW to 15-20 MW (required for baseline) while maintaining capability for capacity increases as required.
11. Increase demineralized water system pressure from 125 psig minimum to 210 $\pm$ 20 psig (for gyrotron cooling).

APPLICATION:

NEXT ASSEMBLY 70A370000

MODEL 1056

SPECIFICATION NO. 70P374002

FSCM NO. 76301

DATE 18 December 1980

REV. D - 7 APR 1982

PROCUREMENT SPECIFICATION FOR

DEVICE UTILITIES

DRAFT

PREPARED BY: 18 Dec. 80
D. T. Erickson, Manager
EBT-P Installation and Test

APPROVED BY:
J. B. Browne, Group Engineer
Engineering Contract Services

APPROVED BY: D. W. Haas for 12/18/80
H. F. Imster, Manager
EBT-P Engineering

APPROVED BY:
R. J. DeBellis, Manager
EBT-P Project

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY - ST. LOUIS
ST. LOUIS, MISSOURI 63166

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for
Device Utilities

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SPECIFICATION NO. 70P374002
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DATE - 18 DEC 1980 ISSUE
REV. B - 31 JULY 1981
REV. C - 6 NOV 1981
REV. D - 7 APR 1982

Revision C incorporates CNR's D-001 (Partial) D-006, D-007, D-010, and reflects PDR comments.

Prepared By: D. T. Erickson 20 Nov 81
D. T. Erickson
EBT-P Site Manager

Approved By: Harry F. Imster 23 Nov 81
H. F. Imster
EBT-P Engineering Manager

Approved By: J. B. Browne
J. B. Browne
Engineering Contract Services

Approved by: R. J. DeBellis 11/24/81
R. J. DeBellis
EBT-P Project Manager

Revision D incorporates general updates and additional PDR comments (dated 1-18-82).

Prepared By: D. T. Erickson
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EBT-P Site Manager

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Approved By: J. B. Browne
J. B. Browne
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Approved By: R. J. DeBellis
R. J. DeBellis
EBT-P Project Manager

A. L. Boch per Letter
Dated 13 Jan 1982

Approved By: ______________________
A. L. Boch
EBT-P Project Manager
UCC-ND

SPECIFICATION NO. 70P374002
FSCM NO. 76301
DATE - 18 DEC 1980 ISSUE
REV. B - 31 JULY 1981
REV. C - 6 NOV 1981
REV. D - 7 APR 1982

1.0 SCOPE - This Procurement Specification (P.S.) defines the minimum requirements for the performance, design, fabrication, installation and testing of the device utilities system at the VIP site for use in the Elmo Bumpy Torus - Proof of Principle Fusion Energy Experiment. Demineralized water and/or cooling tower water is employed for cooling EBT-P systems such as the toroidal vessel, the microwave system, helium liquefaction/ refrigeration systems, HVAC system, and other systems requiring water cooling. Primary 13.8 KV electrical power from the City of Oak Ridge Valley Industrial Park substation shall be provided through new 15-KV switchgear on the site. The 13.8 KV feeders from the switchgear to the EBT-P power supplies and utilities are included as part of this specification.

2.0 APPLICABLE DOCUMENTS

2.1 DOCUMENTS - The Design of the device utilities system for the Elmo Bumpy Torus - Proof of Principle Device, hereafter referred to as EBT-P, shall be in accordance with the latest additions of all applicable codes, standards, regulations, and other pertinent documents of all local, state, and national government agencies having jurisdiction, and of commonly accepted trade organizations. See Figure 6 for the primary support associated codes and specifications. These documents include, but shall not be limited to, the following:

American Institute of Electrical and Electronic Engineers (IEE)

- o Standards

American Institute of Steel Construction

- o Specifications and Standards

American Society of Mechanical Engineers (ASME)

- o Boiler and Pressure Vessel Code, Section VIII, Division 1, "Pressure Vessels."
- o Boiler and Pressure Vessel Code, Section IX, "Welding Specifications".

American Welding Society (AWS)

- Standards

American National Standards Institute (ANSI)

- Standards

American Society for Testing and Materials (ASTM)

- Specifications

Compressed Gas Association (CGA)

- P-1, Safe Handling of Compressed Gases in Containers
- Compressed Gas Handbook

Federal Aviation Administration Grounding, Bonding and Shielding Practices for Electronic Equipment and Facilities

- FAA-RD-75-125 Vols I, II and III (AD-A022-322, AD-A022-600, AD-A022-871
- USAF Regulation 161-35 Hazardous Noise Exposure

Instrumentation Society of America

- ISA-S5.1 1973, Standard Instrumentation Symbols and Identification

Insulated Power Cable Engineer's Association

Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

- SP-61, Hydrostatic Testing of Steel Valves
- SP-25, Standard Marking System for Valves, Fittings, Flanges, and Unions

National Bureau of Standards

National Electrical Code

National Electrical Manufacturer's Association

- NEMA Standards for Electrical Controls

National Electrical Safety Code

- Handbook S1

National Fire Protection Association (NFPA)

- Fire Codes
- NFPA 101 Life Safety Code

National Plumbing Code

- National Standard for Plumbing Construction

Occupational Safety and Health Act (OSHA)-

The Pipe Fabrication Institute (PFI)

- ES4, Standard Practice, Shop Hydrostatic Testing of Fabricated Piping
- ES5, Standard Practice, Cleaning Fabricated Piping
- ES11, Recommended Practice for Permanently Affixing Identification Symbols to Fabricating Piping

U.S. Department of Energy (DOE)

- ERDA Manual, Chapter 0550, Occupational Safety Standards

Underwriter's Laboratory (UL)

- Lists of Inspected Appliances, Equipment, and Material

Tennessee State and Local Building Safety Codes

Uniform Building Code

- Seismic Zone Number 2

Union Carbide Corporation - Nuclear Division (UCC-ND)

- General Design Criteria for UCC-ND Projects (ORNL), Y/EF-538/R4

Harris Computer Systems

- Site Preparation Preinstallation Guide 088002-002, Change 2 August 1979
- EBT-P Proposed Reference Design Report, Section 4.0 (applicable portions thereof)

McDonnell Douglas Astronautics Company - St. Louis

- 70J374000 EBT-P Facilities Layout
- 70P374003 Procurement Specification for EBT-P Facilities
- Memo EBT-219, EBT-P Facility Preliminary I and C System Grounding Requirements
- Memo EBT-240 EBT-P Facility High Frequency Ground System Requirements
- 70B375000 EBT-P Water Manifolds/Interface

- o 70B371013 EBT-P Coolant Manifolds/Interface, Gyrotrons 1st Level
- o 70B372002 EBT-P Support Structure, Primary

2.2 PRECEDENCE - When the requirements of the procurement specification and referenced documents are in conflict, the following shall apply:

a) Procurement Specification - This Procurement Specification shall have precedence of all referenced documents.

b) Referenced Documents - Any referenced documents shall have precedence over all documents referenced therein. Contradictory requirements from two or more referenced documents shall be brought to the attention of the buyer for resolution.

2.3 PARAGRAPH REQUIREMENTS - Where paragaphs of this specification or any other document are referenced herein, all subparagraphs of referenced paragraphs shall be applicable unless otherwise noted.

3.0 REQUIREMENTS

3.1 DEFINITION - The Device Utilities system for the EBT-P provides demineralized cooling water, cooling tower water, provides and distributes high and medium voltage power, device related lightning protection and instrumentation and rf grounding, instrument air, and the device enclosure (Ref WBS 3.7) elements of the total EBT-P system. EBT-P is a toroidal device with a 4.5 M major radius and 36 sectors. Each sector consists of a superconducting magnet and mirror cavity section. The toroidal vessel is rough pumped through a vacuum port, and to very low pressures via 9 additional vacuum ports distributed throughout other mirror cavities. The plasma within the toroidal vessel is heated by both RF and microwave power. The microwave power is generated by gyrotron tubes and transmitted and distributed to the toroidal vessel by microwave waveguides.

The RF power is generated by power amplifiers and transmitted into the toroidal vessel by large rigid coax transmission lines connected to antennas within the toroidal vessel. The plasma within the toroidal vessel is contained by a magnetic field generated from 36 mirror coil magnets. The global field error correction coils are employed to fine tune the toroidal magnetic field.

In many cases the device utilities described herein shall interface directly with WBS 5.0 Facility Elements such as at switchgear, concrete pads, domestic water lines, etc.

3.2 DEVICE UTILITY SYSTEM DESCRIPTION - The device utilities baseline shall provide support to, but not be limited to, the following elements.

a) Demineralized cooling water shall be stored, cooled, and be circulated to the following EBT-P system elements (Note: The appropriate device systems shall provide all interconnects to and from, other than device utilities, device items as described herein:
   1. Mirror Coil Vacuum Liner Cooling Lines (36)
   2. Mirror Cavity Cooling Lines (36)

3. Limiters (144)
4. Vacuum Port Microwave Shields (5)
5. Gyrotron Tubes -8 each (2-28 GHz; 6-60 GHz)
6. The Microwave Waveguides (8 each) Cooling Lines
7. The RF Power Amplifiers (2-0.5 mW amplifiers)
8. The Global Field Error Correction Coils (4) Cooling Tubes
9. The Turbopumps (9)
10. The Gaseous Helium Compressors (2)

b) Provisions for the following shall be provided in the demineralized water distribution system:

1. ARE Coils (72) - future upgrade
2. ICRH Antennas (2) - future upgrade
3. Additional Plasma Heating to 5 mW - future upgrade
4. RF Tuning (Capacitors) Stubs
5. RF Antenna
6. Gyrotron tubes - 15 each - future upgrade
7. Diagnostics

c) Electrical power and distribution shall consist of the following:

1. The 13.8 KV power shall be distributed through switchgear to the ECRH power supplies on the RF power supply pad.
2. 2.4 KV, 480 V, 240 V, 208 V, and 120 V shall be distributed from the appropriate transformer secondary windings and switchgear to the using devices. The 2.4 KV switchgear shall be included as device utilities (see Figure 3).
3. An uninterruptable power supply shall be provided to supply DC and AC power to critical circuits during primary power outages.
4. Device Related Grounding (i.e., instrumentation and RF) and lightning protection per 70P374003 Procurement Specification for EBT-P facilities.

d) Instrument/Service Air System:
   1. Instrument Air shall be processed, stored, and distributed to pressure, temperature, and flow controllers.
   2. Instrument air shall be distributed to all cryogenic, vacuum, and cooling water remote actuated valves.
   3. Air shall be distributed to all shop and laboratory areas for general air tools drive, testing, cleaning, and drying.

e) Cooling Tower System:
   1. A cooling tower system shall be provided to reduce the cooling water temperature.
   2. A heat exchanger shall be provided to cool the demineralized water with cooling tower water.
   3. Cooling tower water shall be distributed to the instrument air compressor.

f) Device Enclosure System:
   1. The device enclosure system is described in 70P374003 procurement specification for EBT-P facilities. Any equipment/material placed within the device enclosure shall be compatible to 10^8 rads gamma radiation exposure.

3.3 GENERAL REQUIREMENTS

3.3.1 Demineralized Water

a) All equipment and devices comprising the device utilities system shall be capable of safe, reliable operation, and performance in accordance with this specification over the anticipated 10 year life.

b) All subsystems (i.e. lines, tanks, etc.) located outdoors shall be weather proofed (freezing shall be prevented).

c) Bi braze joints (or equivalent) flanged, and/or screw joints shall be used for dissimilar metals joining.

d) All fluid circuits shall be provided with pressure relief valves.

e) All carbon steel internal piping and tanks surfaces shall be primed in accordance with UCC-ND Interim Paint Specification, Para. 3B, using DuPont No. 759 paint. Tank internal surfaces may be protected by alternate approved means.

f) All other carbon steel surfaces shall be sandblasted and painted with a rust inhibiter.

g) All flanged piping shall employ ground straps between piping segments.

h) All valves shall be designed to fail in the "safe position" in the event of an electrical or instrument air failure.

i) All pneumatically operated controllers and/or valves shall be designed to operate with 100 psig instrument air (regulation to lower pressures by dedicated pressure regulators is permissible).

j) All equipment, lines and components shall be fabricated in sections consistent with shipment and installation considerations so as to minimize field connections.

k) All demineralized water piping shall be stainless steel, properly primed carbon steel, or copper. No aluminum shall be in contact with the demineralized water.

l) The demineralized water shall be stored in a 50,000 gallon storage tank. Capability to determine quantities, both locally and remotely, within shall be provided by suitable signal-transmitting transducers. This tank shall have a siamese fitting available for Oak Ridge Fire Department pumper connection.

m) All demineralized water lines shall be routed and secured in the most economic manner consistent with minimizing pressure losses. Lines shall be supported and secured to permit 100°F maximum thermal differentials. Supports shall be sized and spaced based upon static and dynamic loads.

n) The demineralized water supply and return sources for each EBT-P device element shall be routed to defined interfaces close to the using element.

o) Appropriate device systems shall provide the link between the supply and return manifold to the actual EBT-P device interface.

p) Installed instrumentation within the demineralized water system shall consist, for each circuit: a flowswitch, a pressure signal transmitting transducer, and inlet and outlet thermocouples. Flowmeters shall be installed in major cooling water branches.

q) A demineralized water surge (makeup, compliance and head) tank shall be provided. Capacity shall be adequate to accomodate sampling panel usage, filters, backflush and demineralizer bed backflush.

r) All elements within the demineralized water system on the device side of the isolation valves shall be capable of being evacuated to less than 1 psia.

s) Each primary circuit shall be provided with high point bleeds and low point drains to facilitate priming and draining, respectively.

t) All flanges or ports provided for device or facility interfaces shall be plugged or capped with appropriate pressure rated fittings and related seals. Note: Teflon tape or other particulate generating seal materials shall be excluded from use on any port or flange.

u) At the flowrates noted in Section 3.3.2, the minimum water static pressure at the device interfaces shall be 120 ± 12 psig except for the gyrotron cooling manifolds which will be 210 ± 20 psig.

v) When not in service, the demineralized water system shall be provided with devices to eliminate drain back and loss of prime.

w) All transducers shall be signal-transmitting types.

x) All device utility control and instrumentation wires shall be terminated in a NEMA 12, double door enclosure in the Mechanical Equipment Building.

3.3.2 Demineralized Water Design Maximum Heat Loads and Minimum Flow Rates

3.3.2.1 Toroidal Vessel - The Toroidal vessel maximum upgraded heat rejection is 5.0 megawatts (MW) (1.6 MW startup) and shall require 2,500 gallons per minute (GPM).

3.3.2.2 ECRH - The ECRH maximum heat rejection is 6.0 MW and shall require 6,300 GPM distributed to at 210±20 psig 15 gyrotrons and related support equipment as shown in Figure 1.

3.3.2.3 Helium Compressors - The He compressors maximum heat load is 1.5 MW and shall require 750 GPM.

3.3.2.4 ICRH - The ICRH power amplifiers maximum heat load is 2.0 MW and shall require 1000 GPM.

3.3.2.5 Global Field Error Correction Coils - The global field error correction coils maximum heat load is 0.5 MW and shall require 250 GPM.

3.3.2.6 ARE Coils (future upgrade) - The ARE coils maximum heat load is 8.3 MW and shall require 4150 GPM.

3.3.2.7 ICRH Tuner and Antenna (future upgrade) - The ICRH antennas maximum heat load is TBD MW and shall require TBD GPM.

3.3.2.8 Diagnostics - 1 inch dia. supply and return pipes shall be provided to the south east corner of the device enclosure 2nd level as shown in Figure 4.

3.3.3 Radiation Tolerance

3.3.3.1 All materials and/or equipment located within the device enclosure boundaries shall have a demonstrated ability to 2 x 10^8 rads gamma ray radiation exposure with no degradation. If this is not feasible to attain, appropriate gamma ray shielding shall be provided.

3.4 DEMINERALIZED COOLING WATER SOURCES

3.4.1 Demineralized Water - Shall be available through two parallel 120±12 psig 10,000 GPM pumps and two parallel 210±20 psig 5000 GPM pumps in series with the main pumps; operating singly or together, located in the mechanical equipment building.

3.4.2 Demineralized Water Cooling - A cooling-tower water to demineralized water heat exchanger capable of exchanging 17 MW at 18°F ΔT, maximum, shall be located in the mechanical equipment building. This heat exchanger shall be adaptable to future capacity increase to 37 MW or more.

3.4.3 The Distribution of Demineralized Water - Shall be compatible with available flow capacities pressure drops, controls, and cost effective distribution to all elements described herein. Water lines will be provided to the following area's/systems: external (power supply pad) crowbar/regulators, diagnostics, ICRH power amplifiers, magnet power supplies, diagnostic laboratories. See Figure 4 for a distribution system description.

3.4.4 Oxygen Removal Units - A vacuum degassifier unit shall be made in the water makeup line to the recirculation system in the mechanical equipment building. Additionally, hydrazine will be added to the demineralized water as determined by oxygen content for scavaging and pH control.

3.4.5 Demineralized Water Purifier - A regenerative demineralized water demineralizer shall be provided and interconnected in the recirculation system in the mechanical equipment building to maintain the following:

a.	Conductivity	<0.1 micromho
b.	pH	6-8.5
c.	Total dissolved solids	<0.2 ppm
d.	Dissolved oxygen	<0.5 ppm
e.	Sodium	<0.1 ppm
f.	Chloride	<0.1 ppm

3.4.6 Demineralized Water Makeup - Provisions for two (2) rented (Culligan or equivalent) commercial demineralized water makeup units, installed in parallel, shall be provided. This shall include the supply of process water at 100 GPM minimum, through manual valves, to the conditioners and then introduction into the demineralized water storage tank. These rented units shall deionize the bulk water within the tank to 5.0 micromho's maximum. An activated charcoal bed for chlorine removal may be installed upstream of the rented resin bed demineralizers.

3.4.7 Filtration - A filter of 100 micron absolute rating, with replacable elements, shall be provided. A resin trap shall be incorporated-downstream of the demineralizer. All line sections, components, and tanks shall be cleaned to a particulate level of not greater than 100 micron and shall be solvent cleaned of all nonvolital residues prior to assembly. Cleanliness shall be maintained during assembly.

3.5 COOLING TOWER SYSTEM

3.5.1 Capacity - A 17 megawatt minimum at 18 F° ΔT rated mechanical draft cooling tower shall be installed and the provisions for subsequent capacity increase by additional towers shall be provided.

3.5.2 Cooling Tower System - The cooling tower water system includes all associated piping, pumps, instruments, controls, and chemical treatment necessary to ensure effective system performance during all environmental extremes anticipated at the EBT-P facility.

3.5.3 Distribution - The cooling tower water shall be distributed to and from the demineralized water heat exchanger in the mechanical equipment building. All subsystems (i.e., tanks, lines, etc.) located outdoors shall be protected against freezing.

3.5.4 Fire Protection - The cooling tower shall be provided with an automatically actuated deluge system. The system shall supply the minimum application rates as follows:

a. .33 GPM per ft^2 under the decks including the fan opening.

b. .5 GPM per ft^2 over the fill area.

3.5.5 Air Compressor - The cooling tower water shall be distributed to and from the air compressor.

3.5.6 Makeup - Cooling tower water makeup shall be provided.

3.5.7 Chemical Treatment - A chemical treatment system shall be incorporated to control fungus, algae, and other growth in the system.

3.6 OPERATIONS

3.6.1 The Controls - Controls shall be provided to permit operation of individual systems, and system elements, without impact to other systems or systems elements.

3.6.2 High Point Ullage Traps and Low Point Water Traps - Shall be minimized to the greatest extent possible.

3.6.3 Priming - To ensure adequate demineralized water system priming, hand valves and ports shall be provided at, or near, the high point of each demineralized water circuit. Evacuation to less than 1.0 psia will be performed to accomplish the elimination of ullages within the EBT-P device demineralized water systems. MDAC-STL will provide the evacuation equipment.

3.7 ELECTRICAL POWER DISTRIBUTION SYSTEM

3.7.1 Power Source - 13.8 KV power shall be provided to the site from the Valley Industrial Park City of Oak Ridge Electrical Division intake power substation. See Figure 3 for a definition of the facility/device utility interfaces.

3.7.2 13.8 KV Switchgear and Distribution - This 13.8 KV power shall be routed through facility switchgear and by copper bus or cables to device ECRH fused disconnects near the ECRH units and device 13.8 KV ICRH power supplies switchgear on the power supply pad.

3.7.3 13.8 KV - 2.4 KV Transformer - The transformer secondary output shall be distributed through device utility 2.4 Kv motor control center and conduit to:

3.7.3.1 Demineralized water boost pumps in the mechanical equipment building.

3.7.3.3 Demineralized water pump(s) in the mechanical equipment building.

3.7.3.4 He compressor A and B motors (2) in the mechanical equipment building.

3.7.3.5 Cooling Tower Pumps A and B.

3.7.4 13.8 KV - 480/240 V Transformers - The transformers secondary output shall be distributed through facility motor control centers to device utility cables and conduit to:

3.7.4.1 Deleted.

3.7.4.2 Terminal boxes with switchgear near the mirror coil magnet power supplies in the test support building.

3.7.4.3 Terminal boxes with switchgear near the cooling tower water pumps.

3.7.4.4 Terminal boxes with switchgear near the cooling tower fans.

3.7.4.5 Terminal boxes with switchgear near the cold box in the mechanical equipment building.

3.7.4.6 Terminal box with switchgear near the instrument air compressor and dryer in the mechanical equipment building.

3.7.4.7 Terminal boxes with switchgear near the global field error correction coil power supplies in the test support building.

3.7.4.8 Terminal boxes with switchgear near the roughing mechanical vacuum pumps (2), roughing roots blowers (2), and turbopump frequency converters.

3.7.4.9 Terminal boxes with switchgear near the gyrotron magnet power supplies in the test support building.

3.7.4.10 A 400 amp battery charger in the test support building for the uninterruptable power supplies.

3.7.4.11 Terminal box with switchgear in the control room for the computers.

3.7.5 13.8 KV - 208/120 V or 480V-208/120V Transformers - The transformers secondary output will be distributed through facility circuit breaker panels to device utility cabling and conduit to:

3.7.5.1 Terminal boxes with switchgear located near the gyrotron magnet power supplies within the test support building.

3.7.5.2 Terminal boxes with switchgear within the control room.

3.7.5.3 Terminal boxes with switchgear for miscellaneous TBD utilities.

3.7.5.4 Terminal boxes with switchgear for turbopump cooling water refrigerators and gyrotron magnet vacuum pumps.

3.7.6 Incoming Power Level - The initial incoming power level will be adequate for startup. Provisions for future upgrade will be included.

3.7.7 Uninterruptable Power - An uninterruptable power supply system will be provided. This will consist of the following:

3.7.7.1 A 480 VAC to 125 VDC, 400 amp, battery charger.

3.7.7.2 125 VDC, 60 cell, 750 amp hour minimum batteries.

3.7.7.3 Deleted.

3.7.7.4 A 125 VDC/120 VAC, 30 KVA, Inverter.

3.7.7.5 Critical 115 V AC power boxes: (1) TSB level 1 south wall of electronic shop with 5-10A circuits; (2) TSB control room north wall with 10-10A circuits; and (3) TSB level 2 north wall of device enclosure with 6-10A circuits.

3.7.7.6 Remote latching switching devices controlled from the control room to enable or disable the backup power to the AC critical bus.

3.7.7.7 Instrumentation to locally and remotely display charger current, battery voltage, critical AC bus voltage, current, and frequency.

3.7.7.8 All facility fire/intrusion detection and protection and communication systems shall be interconnected with the critical bus.

3.8 INSTRUMENT AIR SYSTEM

3.8.1 Compressor - A 420 SCFM at 100 psig instrument air compressor shall be installed in the mechanical equipment building.

3.8.2 Dryer Inlet Filter - An air dryer 3 micron inlet filter shall be interconnected with the compressor discharge.

3.8.3 Dryer - A 35°F dewpoint (maximum) and 420 SCFM air dryer shall be connected to the compressor outlet.

3.8.4 Dryer Discharge Filter - An air dryer 0.1 micron outlet filter shall be interconnected with the air dryer discharge.

3.8.5 Receiver Tank - A 55 actual cubic foot 150 psig working pressure receiver tank shall be connected to the air compressor. This tank shall be automatically maintained at 100±5 psig by pressure switches.

3.8.6 Pressure Gage - A 0 to 200 psig pressure gage and signal transmitting transducers shall be installed on the receiver tank. Pressure signals will be transmitted to the control room.

3.8.7 Relief Valve - A 150 psig maximum relief valve rated at 420 SCFM minimum shall be installed on the receiver tank.

3.8.8 Routing - The instrument air shall be routed in aluminum, or equivalent, tubing to valve controllers, remote actuated valve operators, and shop air quick disconnects in the following systems or areas:

3.8.8.1 Demineralized Water

3.8.8.2 Cryogenics

3.8.8.3 Vacuum

3.8.8.4 Diagnostics - Routed both inside and outside the device enclosure walls with frequently spaced, ~12 foot, capped AN flared male ports per MS33565.

3.8.8.5 Shop Air: Shall be routed in 3/4" tubing to Hansen A3000 quick disconnects. Oil misters shall be installed upstream of the quick disconnects. Quick disconnects shall be distributed to the mechanical equipment building, in the cold box enclosure, within the first and second levels of the enclosure, and within the test support building operations, shops, and laboratories areas.

3.9 DEVICE ENCLOSURE - The Device Enclosure design requirements are defined in the facilities procurement specification 70P374003. Inclusion herein is only for work breakdown structure organization, cost accounting purposes and data submittals.

3.10 DEVICE SUPPORT STRUCTURE

3.10.1 PRIMARY SUPPORT STRUCTURE - The concrete/nonmagnetic stainless steel rebar primary support structure and imbeds shall conform with the requirements depicted in Figures 5 and 6.

3.10.1.1 The envelope dimensions are provided in Figure 5. This figure also defines all MDAC equipment interface details on the primary support structure. The demineralized water supply and return headers supports shall be defined by the seller.

3.10.1.2 The primary support structure design loads are presented in Figure 6. The structural design analysis criteria is also presented. All such analyses, including deflection, shall be provided; for approval, with the design drawings.

3.10.1.3 MDAC-STL shall provide the 70B372008 structural ring segments to the seller for installation, alignment (as directed by MDAC), and grouting.

4.0 QUALITY ASSURANCE PROVISIONS - The ability for the device utilities system defined by this specification to meet the requirements specified in Section 3.0 shall be verified by the performance of inspections, analyses supplied to the buyer, and tests as described herein. The subcontractor shall develop plans for preacceptance testing and inspection prior to shipment. The plan shall include tests which may be conducted at subtier supplier levels, manufacturing in process inspections, and subassembly performance testing as applicable.

The device utilities system acceptance tests shall be performed at the site following installation in the EBT-P facility. The acceptance tests shall be performed in accordance with an acceptance test procedure providing proof tests, leak checks, functional checks, dielectric checks, flow rate verifications, etc. prepared by the subcontractor and approved by MDAC-STL. The use of testing devices such as piping jumper spools and electrical dummy loads shall be employed as required.

The following list describes the generic installation/startup tests for equipment and systems which will be performed for EBT-P. These tests shall include, but not be limited to, the following:

4.1 ELECTRICAL TESTS

a) Wire and Cable

1. High potential test all 5 kV and 15 kV volt cable.
2. Megger test all 480 volt circuits.
3. Continuity check all cable except thermocouple cable.
4. Wring out all control cables and circuits.
5. Check phase rotation of all power cable
   (480 volt cable and above)
6. Visually inspect the integrity of all terminations.
7. Visually inspect and verify proper identification.

b) Oil Filled Power Transformers
   1. Physically check all parts
      a. Check for cleaniness and damage.
      b. Check for correct installation and assembly.
      c. Proper ground.
      d. Visually inspect and verify proper identification of equipment, test points, interface points, servicing points, and controls/monitor.
   2. Complete Checks
      a. Megger all windings.
      b. Check winding continuity and resistance.
      c. Winding ratio check.
      d. Inert gas system.
      e. Tank Leak Test.
      f. Transformer oil processing and testing.

c) Dry Type Transformers
   1. Physically check all parts
      a. Check for cleanliness and damage.
      b. Correct installation and assembly.
      c. Proper ground.
      d. Visually inspect and verify proper identification of equipment, test points, interface points, servicing points, and controls/monitors.
   2. General Checks
      a. Megger all 480 volt transformer windings.
      b. High potential test all high voltage windings
      c. Check winding continuity and resistance.
      d. Winding ratio check.

d) 13.8 kV Switchgear

1. Physical Checks
    a. Check for cleanliness and damage
    b. Correct installation and assembly "red-line" vendor's drawings.
    c. Termination integrity of bus sections and power cable.
    d. Physical checks of breakers to include all cleaning and inspection of breaker that does not require disassembly of the breakers.
    e. Check breaker alignment in the cubicles
    f. Check all fasteners, covers, and connections for tightness.
    h. Visually verify proper identification of equipment, terminations, test points, servicing points, and controls/monitors.
2. Electrical Checks
    a. High-potential test all bus and breakers.
    b. Continuity check of breaker contacts.
    c. Breaker operation test, operating the breaker both electrically and mechanically.
    d. C.T. and P.T. Checks
        1) Ratio checks
        2) Megger check
    e. Perform bus resistance "Ductor" checks.
    f. Check phase rotation.

e) 2.4 kV Limitamp Controller (later)

f) 480 Volt Switchgear

1. Physical Checks
    a. Check for cleanliness and damage.
    b. Correct installation and assembly.
    c. Termination integrity of bus section and power cables.

d. Physically check breakers for cleanliness, will not disassemble the breakers.
e. Check breaker alignment in the cubicle.
f. Check all fasteners, covers, and connectors for tightness.
g. Bus bars connected to proper source.
h. Visually verify proper identification of equipment, terminations, test points, servicing points, and controls/monitors.

2. Electrical Checks
   a. Megger all bus and breakers.
   b. Check continuity of breaker contacts.
   c. Adjust solid state trip using the multi-amp test set-up.
   d. Breaker operation tests, operating the breaker both electrically and mechanically.
   e. C.T. and P.T. Checks
      1) Ratio checks
      2) Megger checks
   f. Perform bus resistance "Ductor" checks.
   g. Check phase rotation.

g) Motor Control Centers
   1. Physical Checks
      a. Correct installation and assembly.
      b. Cleanliness and damage.
      c. Termination integrity.
      d. Check all fasteners, covers, and connectors for tightness.
      e. Bus bars are conventionally connected to their power source.
      f. Visually verify proper identification of equipment, terminations, test points, servicing points, and controls/monitors.

2. Electrical Checks
   a. Megger bus and breakers.
   b. Check ground connections.
   c. Perform resistance "Ductor" checks on the bus.
   d. Check the operation of overloads or multi-amp breakers.

h) Motors
1. Physical Checks
   a. Correct installation and assembly.
   b. Cleanliness and damage.
   c. Bolted connections.
   d. Lubrication and coolant (where applicable).
   e. Termination integrity.
   f. Check for removal of shipping braces and anti-rotation device.
   g. Hand rotate motors before energizing.
2. Electrical Checks
   a. Megger all motors and feeder cable - megger test just before startup.
   b. Polarization index on large motors.
   c. Continuity and impedance check on windings.
   d. Check phase rotation with a meter.
   e. Check equipment ground.
   f. High potential test all 5 kV motors (immediately prior to termination).
   g. Bump motor before coupling.
   h. Performance tests.

i) Batteries
1. Physical Checks
   a. Correct installation and assembly.
   b. Cleanliness and damage.

c. Check all fasteners, covers, and connectors for tightness.
d. Check cell jars for cracks and sediment.
e. Check level and specific gravity of electrolyte.
f. Termination integrity.

2. Electrical Checks
a. Check polarity.
b. Continuity check.
c. Cell voltage
d. Capacity Test.

j) Panels

1. Physical Checks
a. Correct installation and assembly.
b. Cleanliness and damage.
c. Check all fasteners, covers, and connectors for tightness.
d. Termination integrity.
e. Check that proper breakers are used to terminate incoming cables and all breakers physically operate and that proper breakers are in the proper location.
f. Visually verify proper identification of all equipment, terminations, test points, servicing points, and controls/monitors.

2. Electrical Checks
a. Megger all 480 volt buses with feeder cable.
b. Check phase rotation.

k. Communications System

1. Visually inspect each unit for proper installation.
2. Test each handset, amplifier, and speaker and adjust the line balance assembly.

l. Control Logic Test
   1. Electrical Subcontractor will "red-line" drawings of control circuits, etc. to include internal wiring of vendor equipment.
   2. Visually verify proper identification of all equipment terminations, test points, servicing points, and controls monitors.
   3. Functionally verify all control circuit logic including interlocks.

m. Grounding Test
   1. Visually verify proper identification of all grounding points.
   2. Verify correct installation and assembly.
   3. Cleanliness and damage.
   4. Check all fasteners, covers, plates, and studs for tightness.
   5. Termination integrity.
   6. Verify 1 ohm or less resistance from each grounding point to actual ground.

4.2 <u>MECHANICAL TESTS</u>

a. Checks
   Lubrication
   Pump Alignment - Couplings and pipe
   Packing, Seals
   Rotational Checks
   Visual Inspection
   Verify proper identification of equipment, elements, flow direction, media, pressure rating, ASME certification (if required), servicing points, test points, and controls/monitors.

b. Tests

Hydrostatic Tests
Leak Test
System Flush
Blow and Pneumatic Test Air Lines
Lifting Device Proof Tests
Performance Tests for individual pieces of equipment
Calibration of Instruments; bench and loop
Vibration Checks
Stroke Valves
Air Balance HVAC and Test
Test Elevator
System Functional Tests
System Performance Tests

5.0 PREPARATION FOR DELIVERY

5.1 Identification and Marking - Equipment furnished under this specification shall have a suitable name plate attached for identification. The identification and marking shall be in accordance with the best commercial practices. The following data shall be included on the nameplate.

(a) Part name
(b) Manufacturing name and FSCM number
(c) Specification number
(d) Manufacturing serial number
(e) Date of manufacture

All lines will be properly identified for system, supply-return, flow direction, media, usage, and maximum pressure rating.

5.2 Packaging for Shipment - The components of the device utility system shall be packaged in a manner that shall provide adequate protection against corrosion, contamination, damage from shock and vibration and other shipping hazards encountered during handling and transportation. Packaging shall be configured to facilitate handling and inspection.

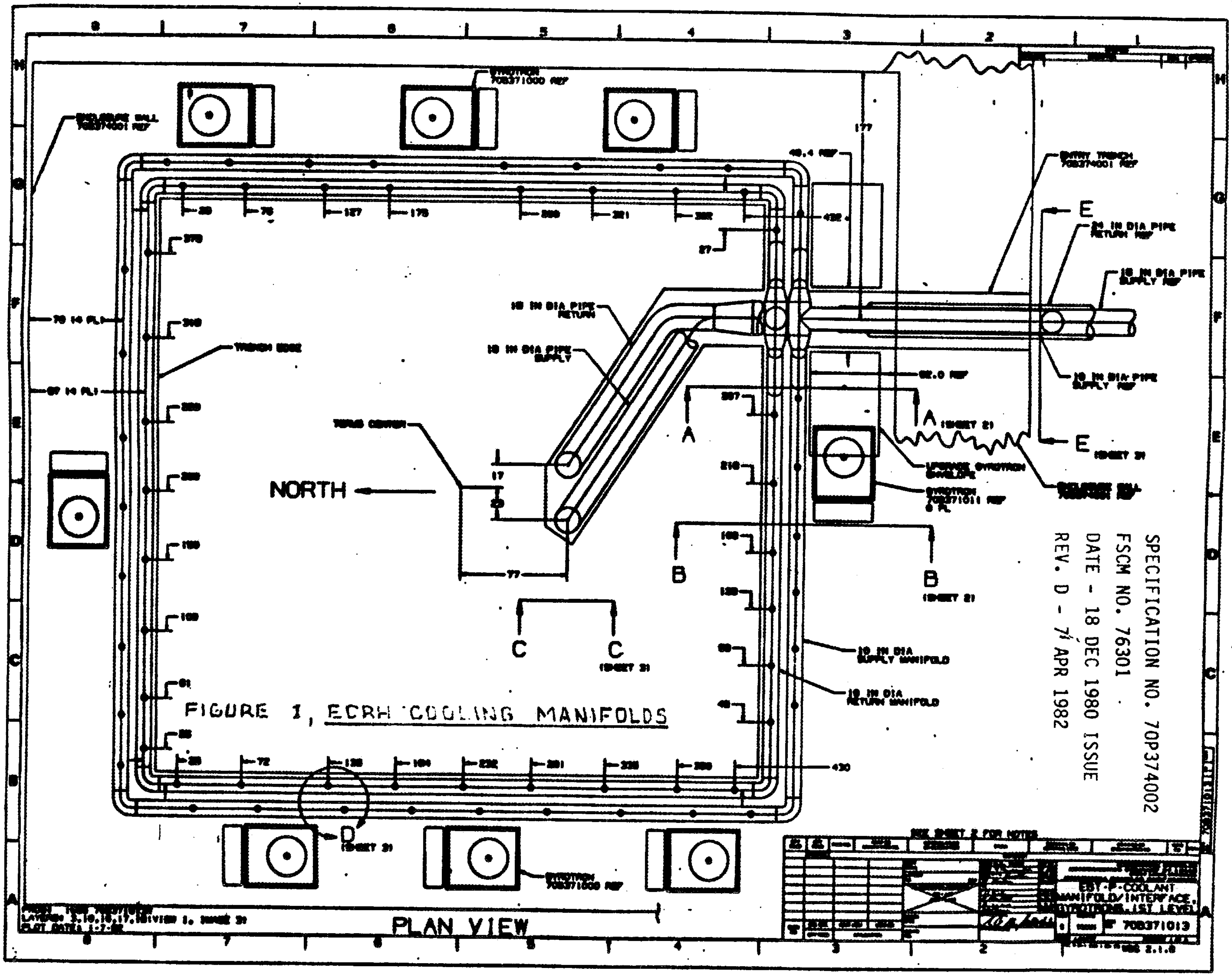

FIGURE 1, ECRH COOLING MANIFOLDS

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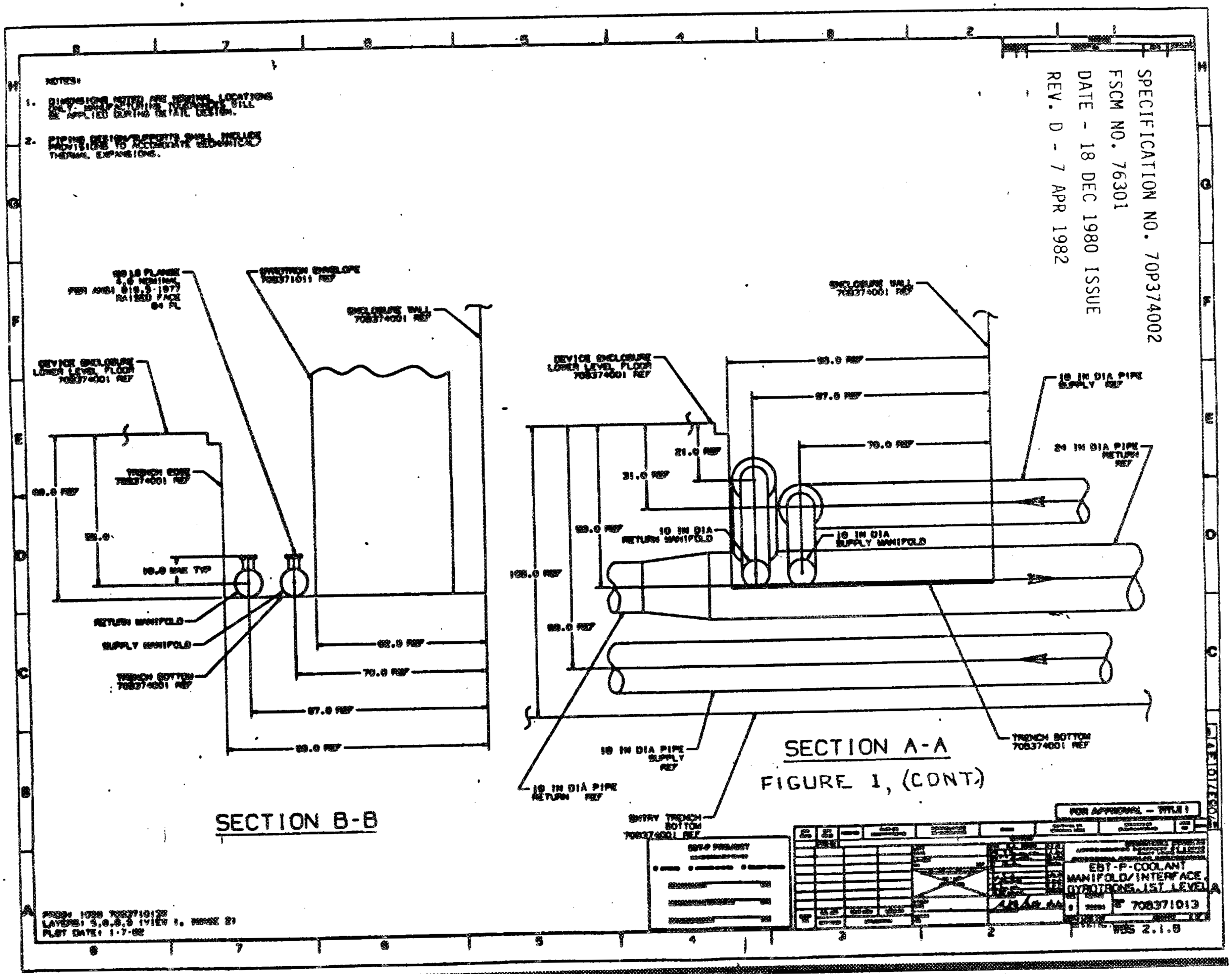
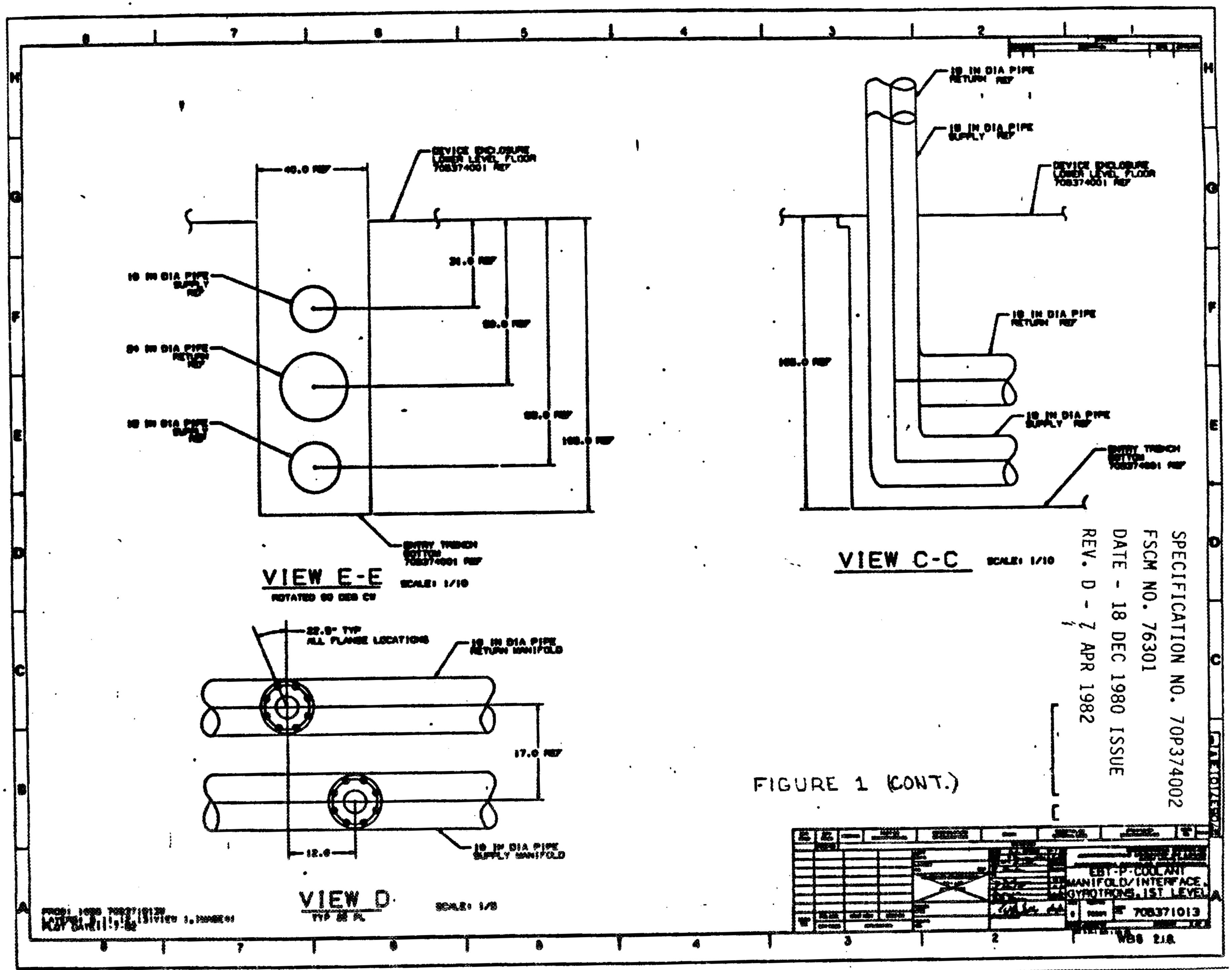


FIGURE 1, (CONT)



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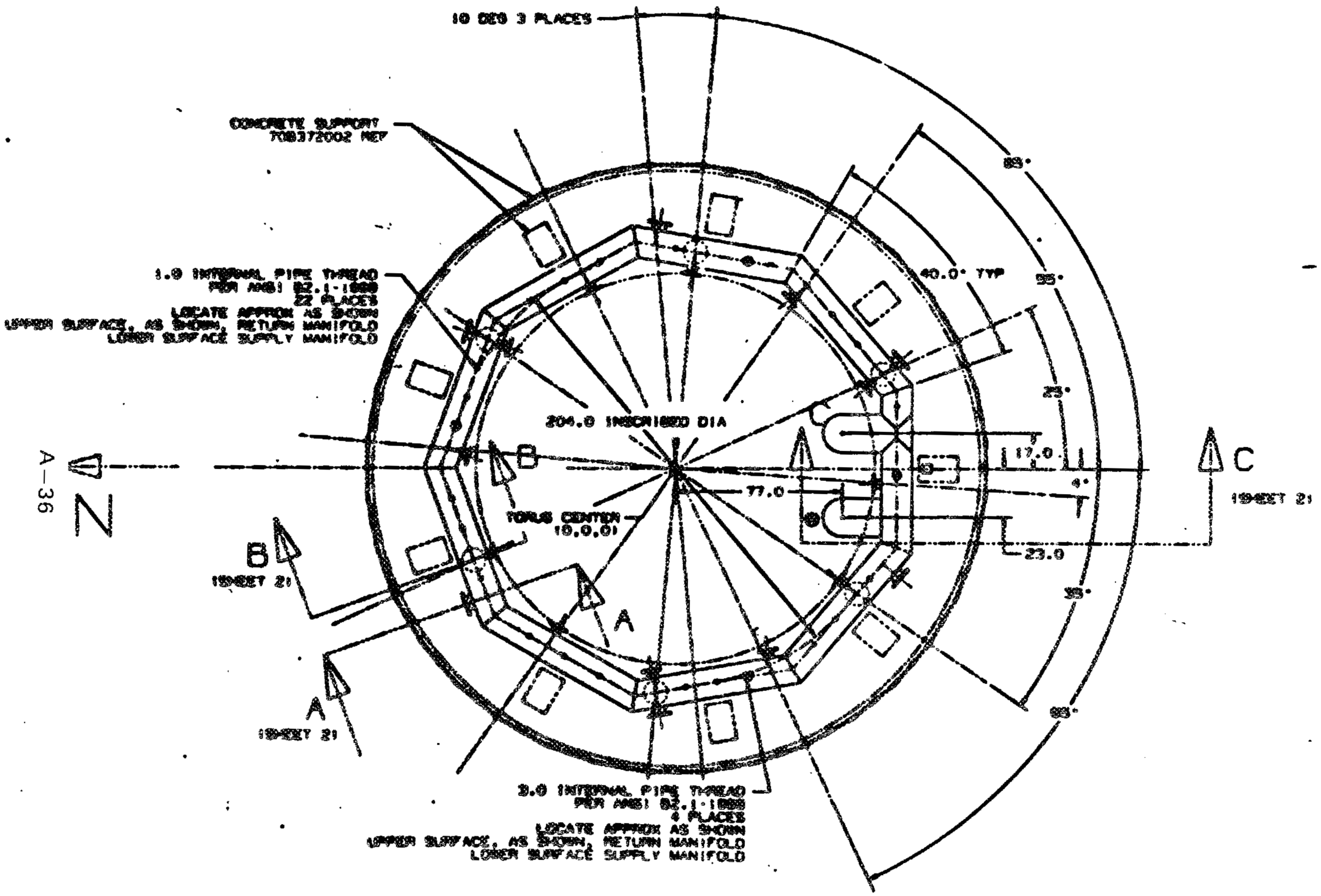
NOTES:

1. DIMENSIONS NOTED ARE NOMINAL LOCATIONS ONLY-MANUFACTURING TOLERANCES WILL BE APPLIED DURING DETAIL DESIGN.
2. PIPING DESIGN/SUPPORT SHALL INCLUDE PROVISIONS TO ACCOMMODATE MECHANICAL/ THERMAL EXPANSION.

A SEE DCN



PLAN VIEW

SCALE: 1/20

FIGURE 2, TOROIDAL VESSEL DEMINERALIZED WATER DISTRIBUTION MANIFOLD

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EBT-DI WATER MANIFOLDS/INTERFACE

76301 70B375000

WBS 2.1.8

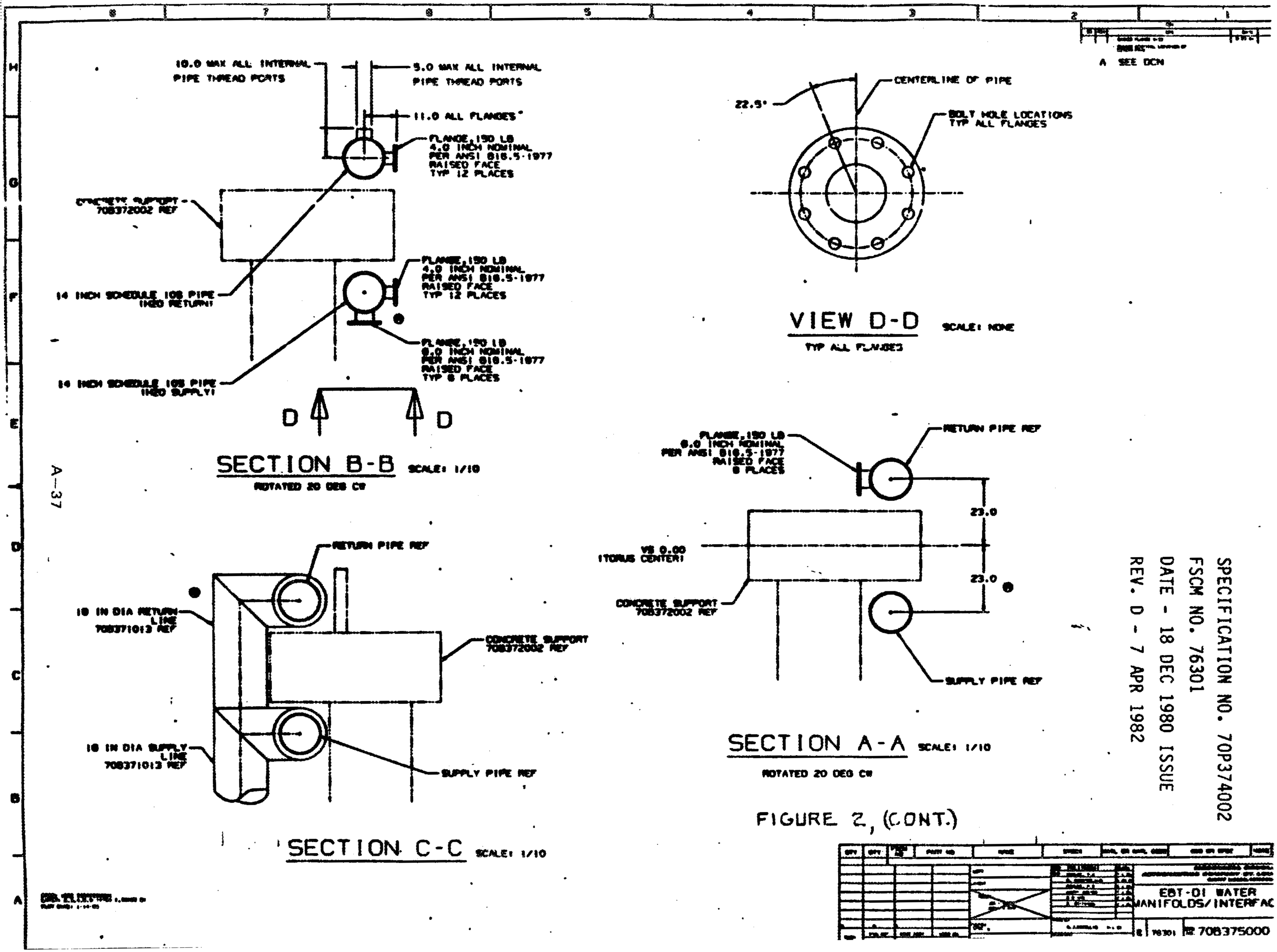


FIGURE 2, (CONT.)

EBT-P FACILITY/DEVICE UTILITY SYSTEM INTERFACES

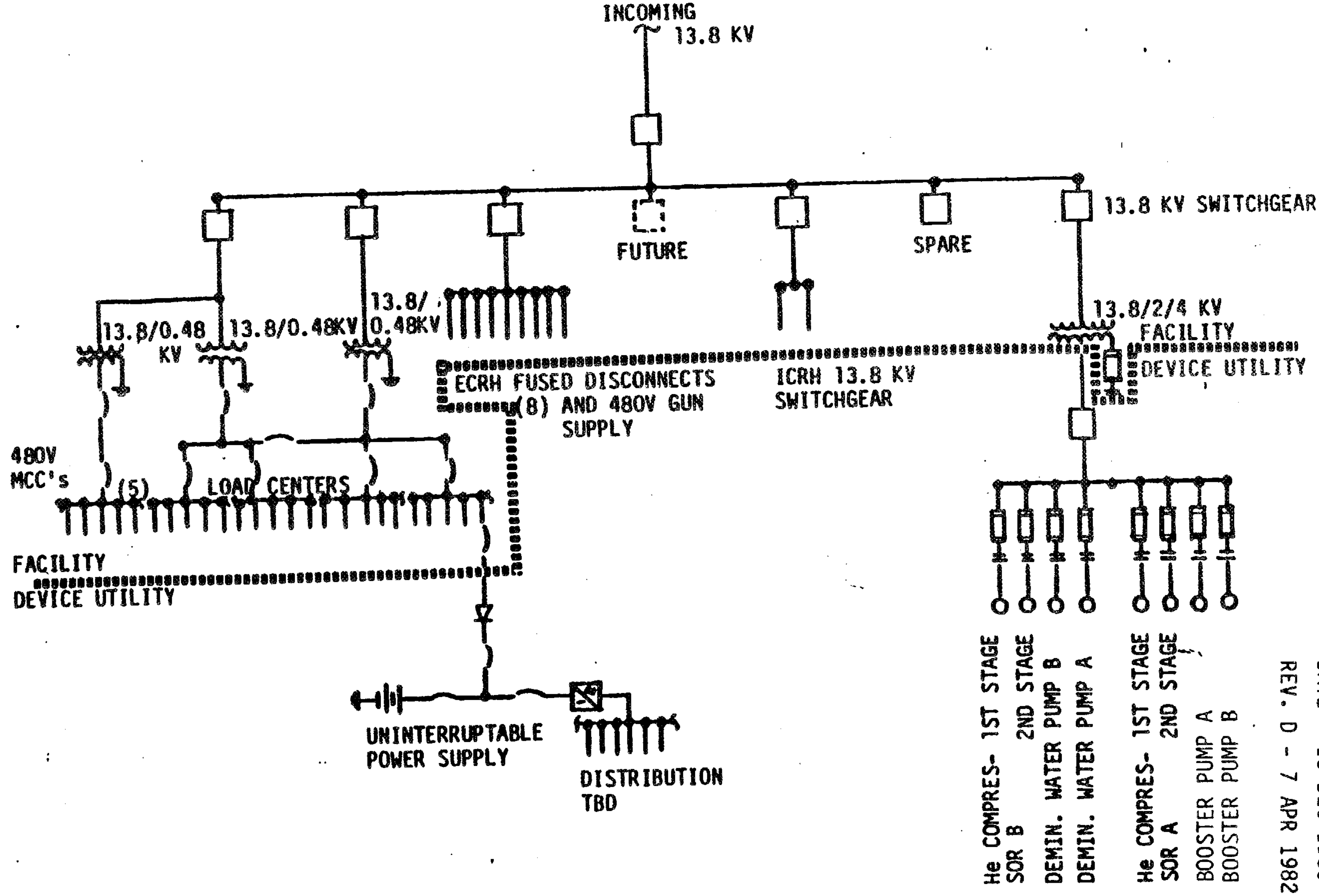
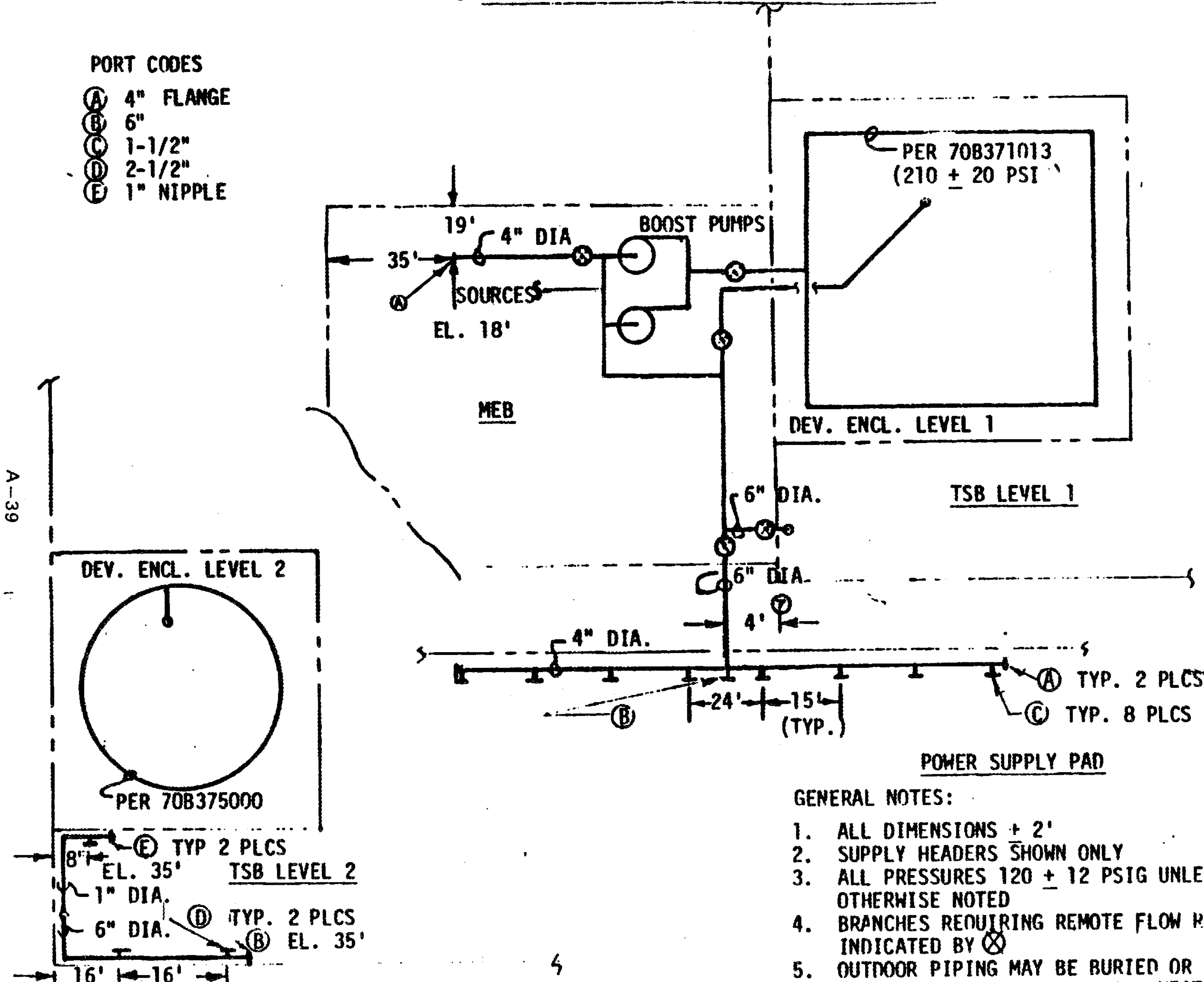


FIGURE 3

SPECIFICATION NO. 70P374002
FSCM NO. 76301
DATE - 18 DEC 1980 ISSUE
REV. D - 7 APR 1982

FIGURE 4, DEMINERALIZED WATER DISTRIBUTION DIAGRAM



GENERAL NOTES:

1. ALL DIMENSIONS ± 2'
2. SUPPLY HEADERS SHOWN ONLY
3. ALL PRESSURES 120 ± 12 PSIG UNLESS OTHERWISE NOTED
4. BRANCHES REQUIRING REMOTE FLOW RATE INDICATED BY ⊗
5. OUTDOOR PIPING MAY BE BURIED OR ROUTED ON POWER CONDUIT SUPPORTS. HEAT TRACING SHALL BE USED AS REQUIRED.
6. PORT CODES - SEE ABOVE

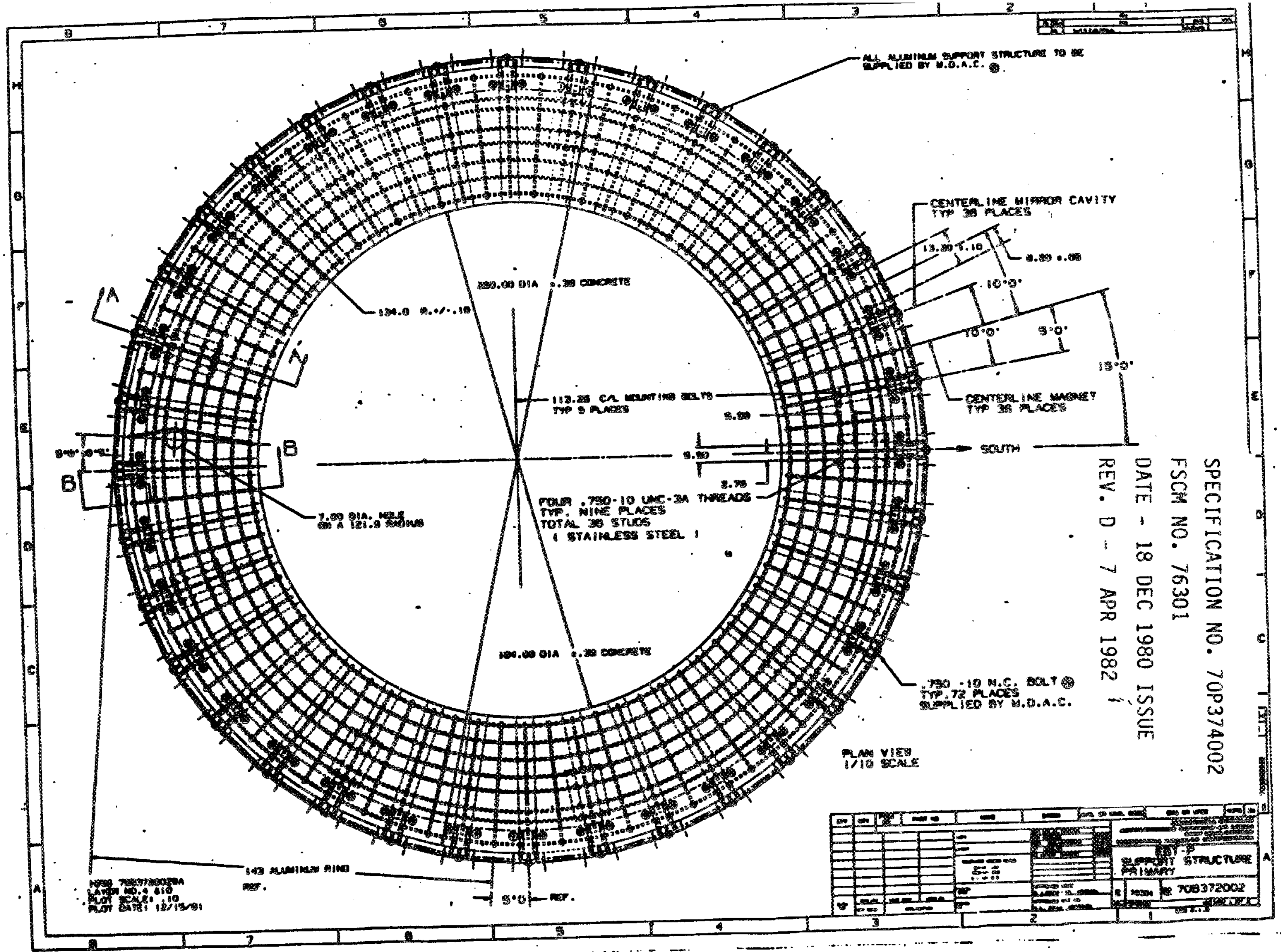


FIGURE 5, SUPPORT STRUCTURE PRIMARY

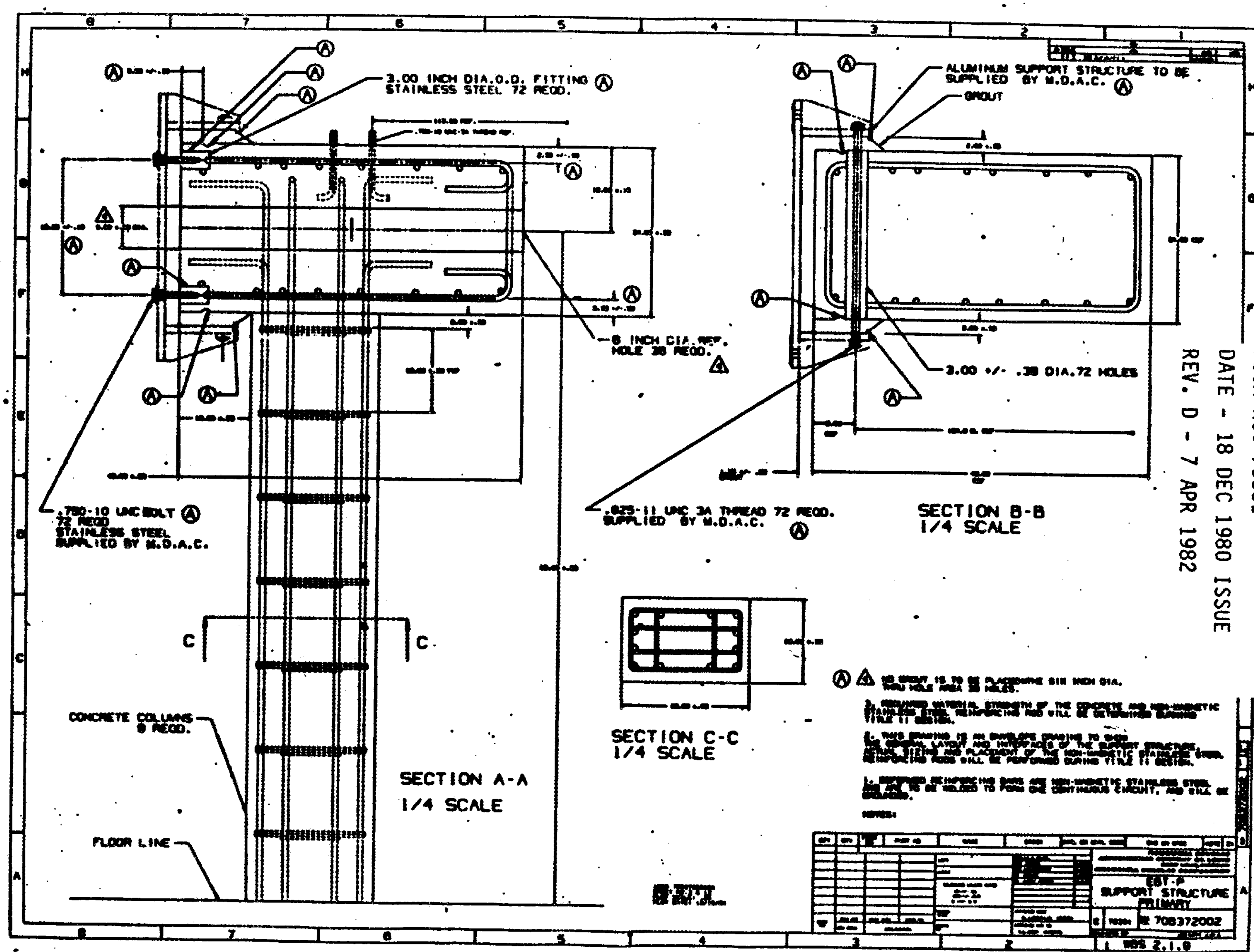


FIGURE 5, (CONT.)

FIGURE NO. 6 PRIMARY SUPPORT DESIGN LOADS AND ANALYSIS CRITERIA

1. CODES AND SPECIFICATIONS

Tennessee State, Anderson County, and City of Oak Ridge

- o Building and Safety Codes

Southern Building Code Congress

- o Southern Standard Building Code (SBC)

American National Standards Institute

- o American National Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures A58.1, Electromagnetic Loading Always Taken to Full Actual Value.

International Conference of Building Officials

- o Uniform Building Code (Only Those Sections Pertaining to Earthquake Seismic Loads Initial Loads Determined Using Regulations, Seismic Zone Number 2) Followed by Response Analysis Verification of Loading.

American Institute of Steel Construction (AISC)

- o "Manual of Steel Construction," AISC, Eighth Edition, 1980 (Elastic Design Method)
- o "Commentary on AISC Specification"
- o Strength Criteria For Stainless Steel Satisfying the Intent of the Manual of Steel Construction

American Iron and Steel Institute (AISI)

- o "Cold-Formed Steel Design Manual," AISI, latest edition.
- o "Specification for the Design of Cold-Formed Stainless Steel Structure Members," 1980 Edition.

American Welding Society (AWS)

- Welding of Bridges, Buildings, and Structures with Tubular Members, AWS D1.1, Latest Edition.

Research Council on Structural Connections

- "Specifications for Structural Joints Using ASTM A325 or A490 Bolts," April 26, 1978.
- Bolting Criteria for our Nonmagnetic Fasteners Satisfying the Intent of "Specifications for Structural Joints Using ASTRM A325 or A490 Bolts."

American Concrete Institute

- Building Code Requirements for Reinforced Concrete ACI 318-77.
- Commentary On ACI 318.

National Concrete Masonry Association

- TR758, Specifications for Design and Construction of Loadbearing Concrete Masonry

Title I

Analyses

The device enclosure shielding analysis conducted by GAI is presented herein. At the writing of this report the GAI shielding analysis and informal analysis conducted by MDAC indicates device enclosure wall thickness of approximately 8 feet (normal concrete) is required. Preliminary requirements from the Argonne National Laboratory provided via telecon are currently being assessed.

An analysis of the effects of strong magnetic fields in cooling water channels is also included herein. While the identified effects may not be applicable to the Device Utility System their may be some detrimental effect present in the toroidal vessel/magnet shields cooling systems.

DEVICE ENCLOSURE SHIELDING ANALYSIS REPORT

EBT-P FACILITY

INTRODUCTION

GAI calculated the Device Enclosure wall and roof thicknesses based upon calculational methodologies which would give the fastest, most cost effective results. More sophisticated techniques may be utilitized; however, the savings to be gained by a slightly thinner wall or roof would be more than offset by the additional engineering and calculational costs and loss of time.

SOURCE TERMS

For calculational purposes, the gamma radiation emitted from the Torus is as shown in Figure 1 (Reference 4). This gives the magnitude and energy spectrun for the gamma radiation source in the toroidal configuration. All calculations were ultimately based upon this source.

SHIELD WALL CALCULATIONS

The Torus was modelled as a cylindrical source having a height equal to the major diameter of the Torus and having a radius equal to the minor radius of the Torus. The cylindrical model was placed tangential to the Torus with the axis of the cylinder parallel to the wall. The source obtained as noted above was assumed to be uniformly distributed throughout the cylinder and the source was assumed to have a density similar to that of air. The source strengths obtained from Figure 1 are:

E(MEV)	(γ/sec)
0.25	1.1 + 17
0.75	2.7 + 16
1.25	1.2 + 16
1.75	5.7 + 15
2.50	4.8 + 15
3.50	1.6 + 15
4.75	6.7 + 14
6.25	1.4 + 14
7.75	2.7 + 13
9.25	3.2 + 12

The SDC Code was utilized to perform the dose rate calculations for the wall (Reference 5). This code uses the point-kernel technique including concrete dose buildup factors for the dose rate calculations. The dose rate as a function of ordinary conrete wall thickness is given in Figure 2.

ROOF CALCULATIONS

To calculate skyshine close rates, it was necessary to calculate the gamma flux distribution through the roof slab above the Torus. This was calculated using the one dimensional discrete ordinates code ANISN-W (Reference 6) and the CASK cross-section library (Reference 7). The design source curve of Reference 4 was collapsed into the 18 gamma groups of the CASK library and a planar shell or flux source was calculated as input for the ANISN Code. The roof was ordinary concrete, type 04 for the ANISN calculations. Thus, an energy dependent gamma flux distribution was generated. The ANISN model which was used allowed for optimization of the roof thickness by providing intermediate slab flux distributions in addition to the one at the outer face. The gamma flux distributions at 5, 6, and 7 feet of concrete are shown in Table 1.

SKYSHINE CALCULATIONS

The gamma fluxes obtained from the ANISN roof calculations discussed above were utilized to obtain a point source for the skyshine calculations.

The skyshine calculations were actually performed utilizing a 1 γ/sec source strength at the following energies: 0.1, 0.4, 0.8, 1.0, 1.5, 2.0, 4.0, 6.0, 8.0, and 10.0 MEV. The results are then multiplied by the point source strength obtained from the ANISN fluxes collapsed into the energy structure used for the skyshine calculations.

The G3 Code was utilized to perform the skyshine calculations (Reference 8). The model employed by the Code was that of a point isotropic source located in the middle of the roof of a 60-foot square building. The dose rate was obtained as a function of distance from the side of the building for each energy. These dose rates are shown in Figures 3 and 4 for the following energy levels: 0.1, 0.4, 1.0, 4.0 8.0, and 10.0 MEV. The complete set of data is found in Table 2.

The skyshine dose rate 50 feet from the side of the building as a function of thickness of the concrete roof slab is presented in Figure 5. Shadow effects and local perturbations of the skyshine are not considered, so that the skyshine dose rate presented is generally considered valid for the entire area.

CONCLUSIONS

The skyshine dose rate limits for this facility have not been specified other than that the direct dose rate and the skyshine dose rate is not to exceed 0.25 mrem/hr (Reference 1). If it is assumed that the skyshine and direct dose rates are allowed to contribute equally to the 0.25 mrem/hr total dose rate, the limit for each becomes 0.125 mrem/hr.

Figure 2 indicates that to reduce the direct dose rate to 0.125 mrem/hr, a wall thickness of 8.3 feet of ordinary concrete is required.

Figure 5 indicates that to reduce the skyshine dose rate to 0.125 mrem/hr, a roof thickness of 5.3 feet of ordinary concrete is required.

CRITERIA AND CODES

(1) Letter from D. T. Erickson to J. N. David, EBT-00022-1/81, dated Janaury 29, 1981.

(2) EBT-P Proposed Reference Design Report, ORNL/TM-7191, APPENDIX 2, x-ray heating.

(3) Memorandum from R. L. Kloster to P. E. Landes/A. P. Munie, EBT-180, dated March 10, 1980.

(4) EBT-P TOTAL X-RAY ENERGY SPECTRUM, D. Erickson, dated April 13, 1981 (EBT gamma source curve transmitted by M. J. Akins, April 14, 1981).

(5) SDC, A Shielding-Design Calculation Code for Fuel-Handling Facilities, by E. D. Arnold and B. F. Maskewitz, ORNL-3041 (1966), Oak Ridge National Laboratory, Oak Ridge, Tennessee.

(6) ANISN-W, MULTIGROUP ONE DIMENSIONAL DISCRETE ORDINATES TRANSPORT CODE WITH ANISOTROPIC SCATTERING, CCC-255, Radiation Shielding Information Center Computer Code Collection, Oak Ridge, Tennessee, September 21, 1977.

(7) CASK, 40 GROUP COUPLED NEUTRON AND GAMMA-RAY CROSS-SECTION DATA, DLC-23, Radiation Shielding Information Center Data Library Collection March 1975, Oak Ridge, Tennesse.

(8) G3-6ED, General Purpose Gamma-Ray Scattering Code, CCC-75, Radiation Shielding Information Center Computer Code Collection June 1973, Oak Ridge, Tennessee.

TABLE 1

GROUP FLUX DISTRIBUTION AT 5, 6, AND 7 FEET OF CONCRETE

GROUP NO.	ENERGY RANGE (MEV)	FLUX DISTRIBUTION (γ/CM^2-SEC) 5' CONCRETE	6' CONCRETE	7' CONCRETE
1	10.0 - 8.0	4.46E + 01	7.57E + 00	1.33E + 00
2	8.0 - 6.5	2.10E + 02	3.31E + 01	5.42E + 00
3	6.5 - 5.0	5.96E + 02	8.61E + 01	1.29E + 01
4	5.0 - 4.0	7.39E + 02	9.69E + 01	1.34E + 01
5.	4.0 - 3.0	1.13E + 03	1.37E + 02	1.79E + 01
6	3.0 - 2.5	7.06E + 02	8.26E + 01	1.05E + 01
7	2.5 - 2.0	8.39E + 02	9.63E + 01	1.21E + 01
8	2.0 - 1.66	6.69E + 02	7.62E + 01	9.57E + 00
9	1.66- 1.33	7.70E + 02	8.72E + 01	1.09E + 01
10	1.33- 1.0	9.64E + 02	1.08E + 02	1.36E + 01
11	1.0 - 0.8	7.43E + 02	8.39E + 01	1.05E + 01
12	0.8 - 0.6	9.81E + 02	1.10E + 02	1.39E + 01
13	0.6 - 0.4	1.90E + 03	2.23E + 02	2.89E + 01
14	0.4 - 0.3	1.35E + 03	1.55E + 02	1.99E + 01
15	0.3 - 0.2	2.40E + 03	2.77E + 02	3.54E + 01
16	0.2 - 0.1	6.26E + 03	7.18E + 02	9.15E + 01
17	0.1 - 0.05	2.46E + 03	2.82E + 02	3.59E + 01
18	0.05- 0.01	1.38E + 01	1.58E + 00	2.01E + 01

TABLE 2

SKYSHINE DOSE RATE AS A FUNCTION OF DISTANCE FROM THE BUILIDNG FOR SELECTED ENERGIES AT 1 γ/SEC

DISTANCE		ENERGY - MEV									
ft.	cm.	0.1	0.4	0.8	1.0	1.5	2.0	4.0	6.0	8.0	10.0
50	1524	2.69-12	3.15-12	3.08-12	2.94-12	2.61-12	2.32-12	1.59-12	1.21-12	9.71-13	4.86-13
100	3048	1.42-12	1.76-12	1.80-12	1.78-12	1.69-12	1.59-12	1.26-12	1.06-12	9.32-13	4.06-13
150	4572	7.99-13	1.01-12	1.00-12	9.89-13	9.50-13	9.04-13	7.44-13	6.44-13	5.75-13	2.60-13
200	6096	4.74-13	6.62-13	6.44-13	6.33-13	6.06-13	5.77-13	4.78-13	4.19-13	3.76-13	1.72-13
250	7260	3.24-13	4.98-13	4.86-13	4.77-13	4.58-13	4.35-13	3.61-13	3.17-13	2.85-13	1.30-13
350	10668	1.23-13	2.44-13	2.48-13	2.45-13	2.38-13	2.26-13	1.88-13	1.65-13	1.49-13	6.59-14
500	15240	3.98-14	1.04-13	1.14-13	1.15-13	1.16-13	1.13-13	9.54-14	8.41-14	7.60-14	3.23-14
750	22860	6.90-15	2.90-14	3.75-14	3.93-14	4.23-14	4.26-14	3.85-14	3.48-14	3.18-14	1.28-14
1000	30490	1.32-15	9.34-15	1.45-14	1.57-14	1.77-14	1.85-14	1.79-14	1.67-14	1.56-14	6.05-15
1500	45720	6.10-17	1.23-15	2.64-15	3.08-15	3.78-15	4.24-15	4.80-15	4.81-15	4.69-15	1.78-15
2100	64008	1.85-18	1.21-16	3.80-16	4.86-16	6.90-16	8.59-16	1.23-15	1.35-15	1.39-15	5.35-16

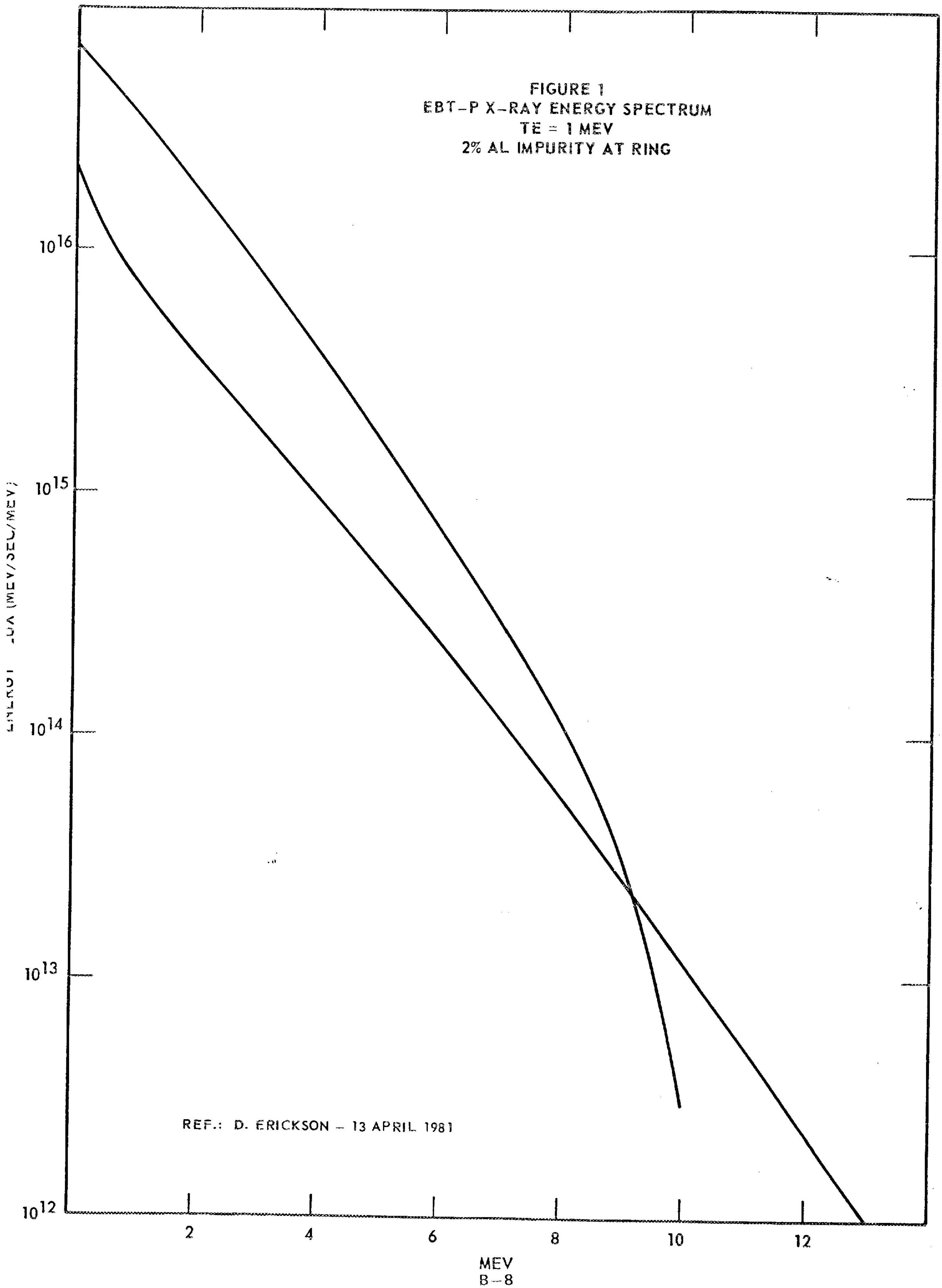


FIGURE 1
EBT–P X–RAY ENERGY SPECTRUM
TE = 1 MEV
2% AL IMPURITY AT RING

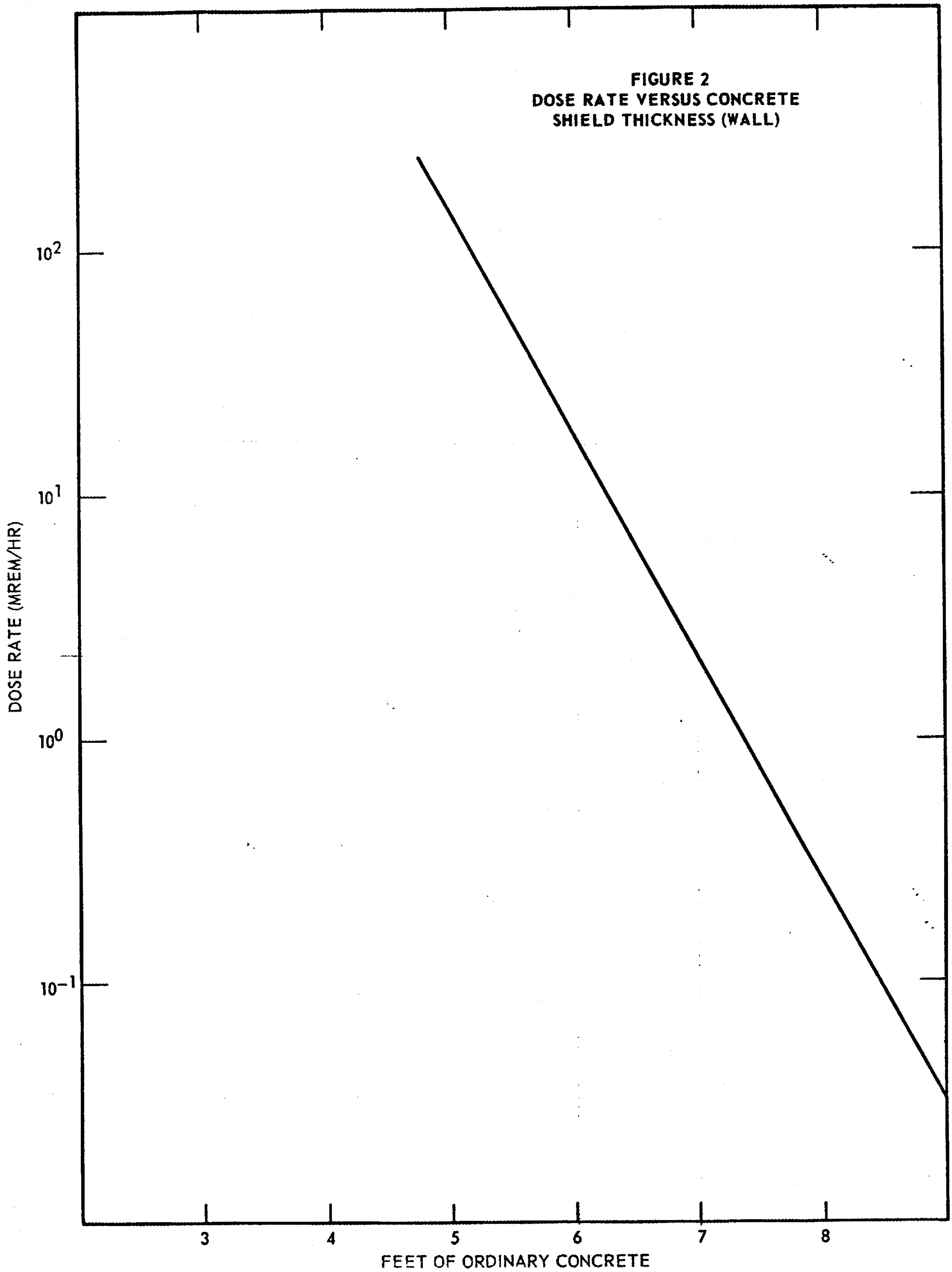


FIGURE 2
DOSE RATE VERSUS CONCRETE
SHIELD THICKNESS (WALL)
DOSE RATE (MREM/HR)
10^2
10^1
10^0
10^-1
3
4
5
6
7
8
FEET OF ORDINARY CONCRETE

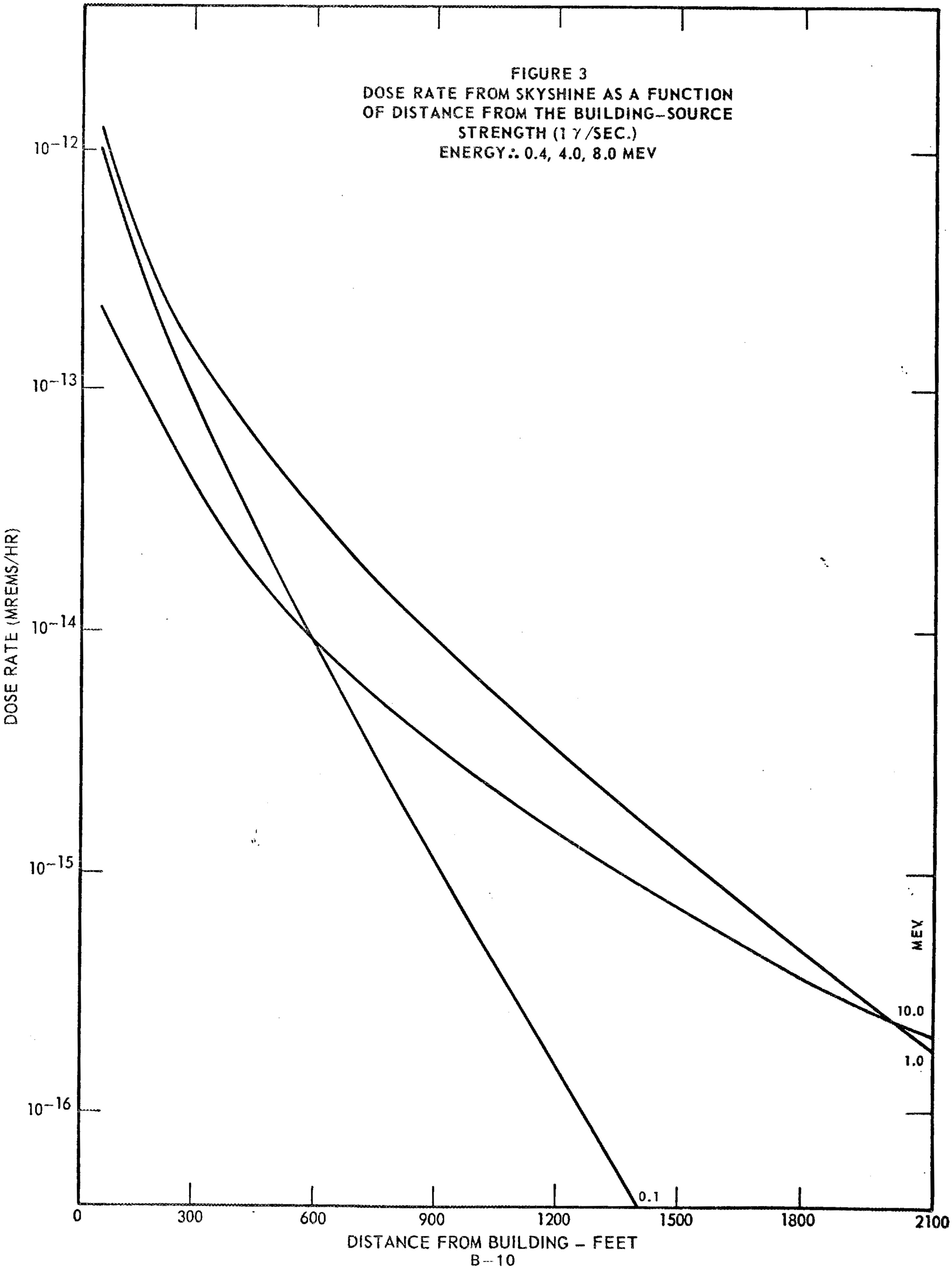


FIGURE 3
DOSE RATE FROM SKYSHINE AS A FUNCTION
OF DISTANCE FROM THE BUILDING–SOURCE
STRENGTH (1 γ/SEC.)
ENERGY∴ 0.4, 4.0, 8.0 MEV
DOSE RATE (MREMS/HR)
10^-12
10^-13
10^-14
10^-15
10^-16
MEV
10.0
1.0
0.1
0
300
600
900
1200
1500
1800
2100
DISTANCE FROM BUILDING – FEET

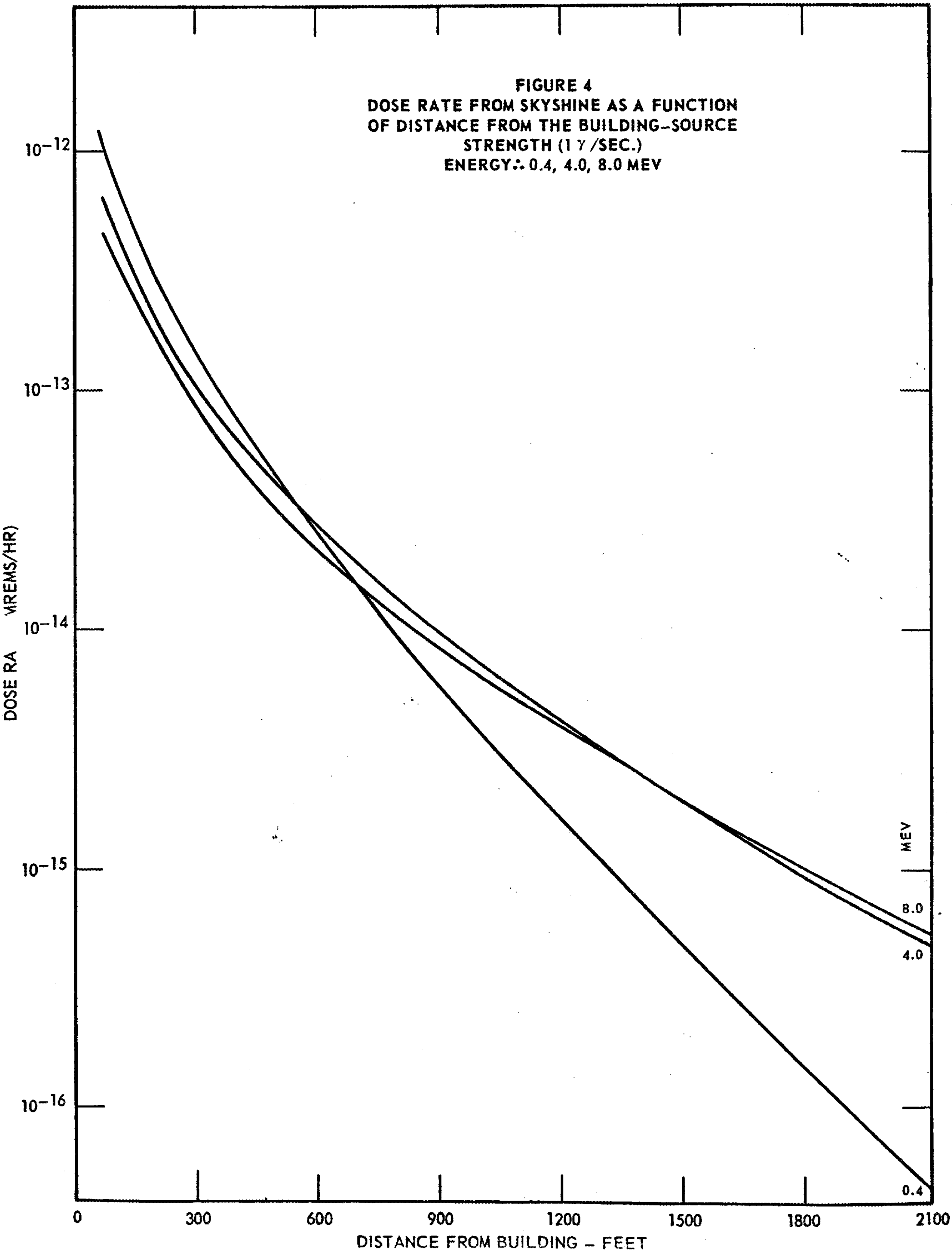


FIGURE 4
DOSE RATE FROM SKYSHINE AS A FUNCTION
OF DISTANCE FROM THE BUILDING–SOURCE
STRENGTH (1 γ/SEC.)
ENERGY∴ 0.4, 4.0, 8.0 MEV
DOSE RA ... MREMS/HR)
10−12
10−13
10−14
10−15
10−16
MEV
8.0
4.0
0.4
0
300
600
900
1200
1500
1800
2100
DISTANCE FROM BUILDING – FEET

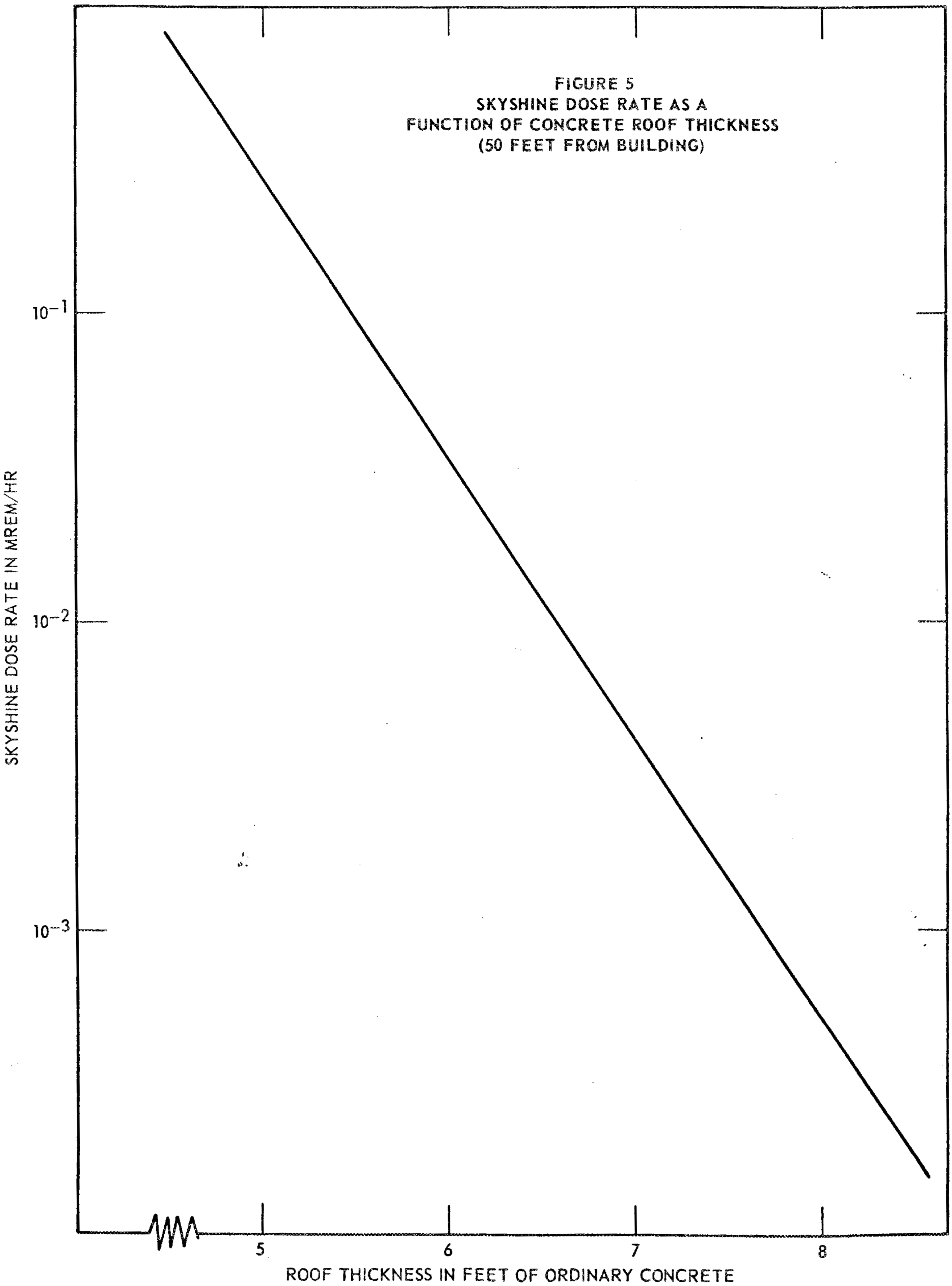


FIGURE 5
SKYSHINE DOSE RATE AS A
FUNCTION OF CONCRETE ROOF THICKNESS
(50 FEET FROM BUILDING)
SKYSHINE DOSE RATE IN MREM/HR
10−1
10−2
10−3
5
6
7
8
ROOF THICKNESS IN FEET OF ORDINARY CONCRETE

MEMO

EBT-310
3 MAR 81

Subject: THE EFFECT OF STRONG MAGNETIC FIELDS ON CORROSION IN COOLING WATER CHANNELS

To: H. F. Imster

CC: J. L. Conlee, R. J. Dannenmueller, J. W. Davis, R. J. DeBellis, G. M. Fuller, R. E. Juhala, J. Kirchner, D. L. Kummer, W. Smith, G. W. Wille

From: G. P. Lang

References: (a) Eugene J. Kelley (ORNL) Magnetic Field Effects on Electrochemical Reactions Occurring at Metal/Flowing-Electrolyte Interfaces, submitted to the Journal of the Electro-Chemical Society.
(b) S. Cantor, W. R. Grimes, ORNL, Fused Salt Corrosion and Its Control in Fusion Reactors, Nuclear Technology, Vol. 22, April 1974, pp 120-126.
(c) M. G. Fontana, N. D. Greene, Corrosion Engineering, 2nd Edition, McGraw Hill Book Company, New York, 1978.

Enclosure: (1) Figure 1 - Maximum Induced EMF and Current Density in Cooling Water Due to Magnetic Fields.

1. The probability that strong magnetic fields will enhance the uniform type of corrosion inside of cooling water channels has been pointed out by Kelly[a] and Cantor and Grimes[b].

> "One half of the cooling pipe will become anodically polarized as its interfacial potential difference moves in the positive (noble) direction, while the other half becomes cathodically polarized. The anodically (+) polarized section might be polarized to the transpassive potential region (for metals that are capable of being passivated), and the cathodically(-) polarized section to the active-passive transition potential region, both potential regions being of enhanced susceptibility to stress corrosion cracking. Further polarization could result in activation of the once passive cathodically polarized section. The anodically polarized section, depending on the specific metal/electrolyte system, could encounter pitting potential or a potential region of enhanced crevice corrosion."

Both the maximum potential generated by the magnetic field in a moving electrolyte and the resulting current are directly proportional to 3 parameters, namely, the magnitude of the field, the thickness of the dialectric coolant fluid, and the velocity of the dielectric fluid. This is shown in Figure 1 for values of the magnetic field, coolant thickness and coolant velocity shown in the EBT-P proposal. Note that the values are independent of the electrical conductivity of either the solution or the metal pipe. The same values of electrical potential or current density are obtained whether the coolant is highly purified water or a concentrated salt solution.

2. It has been given as a rule of thumb[3] that the extent of corrosion is one mil per year (mpy) for a current density of one microampere per cm^2. On that basis, copper or metals that do not passivate may experience uniform corrosion of as much as 0.025 inches per year under the most severe EBT-P conditions, and .005 inches per year under the milder conditions. Whether metals that passivate such as stainless steel will have appreciable less uniform corrosion is not known. Additionally the effect on pitting corrosion or stress corrosion is not known for any of the conditions.

3. Ordinary types of corrosion can be minimized or prevented by a number of measures. These include:

1) Selection of materials that do not corrode in the environment used.

2) Addition of corrosion inhibitors.

3) Cathodic protection, achieved by supplying electrons in the form of a small electric current to the metal structure. This tends to suppress the metal dissolution and increases the rate of hydrogen evolution.

4) Cathodic protection achieved by the use of a consumable or sacrificial anode usually magnesium.

5) Anodic protection achieved by supplying a positive current to oxidize the metal and form a protective oxide coating. This is applicable only to metals that passivate.

6) Coatings

Whether these measures will be effective in corrosion that is due to strong magnetic fields has never been tested. No empirical evidence exists that they will work.

The factors that cause corrosion in a strong magnetic field suggest a number of measures that can be used to control it, namely:

1) Corrosion occurs only if the magnetic field is perpendicular to the flow of the electrolyte. If the flow is parallel no potential or corrosion current is produced. A design that minimizes flow across the magnetic field lines will minimize corrosion.

2) Corrosion is proportional to the thickness of the flowing electrolyte. A design that uses many small channels rather than a few large ones will minimize corrosion.

3) Corrosion is proportional to the velocity of the flowing electrolyte. Lowering the velocity will minimize corrosion.

4) The use of non-conducting coatings or non-conducting materials. If the material cannot sustain a current, no corrosion is possible.

Recommendations:

No exhaustive literature search was made. Only two papers, both from ORNL, were found which treated the subject of enhanced corrosion. Neither of these measured corrosion as such but only the electrical potential and/or current produced in flowing electrolytes by a magnetic field with a maximum strength of 2 tesla. At this field strength corrosion is not very noticable unless carried through for longer periods of time.

In view of the many unknowns it would appear that an experimental investigation of this phenomena be planned and initiated and that this be done with the help and advice of experts in corrosion engineering.

G. P. Lang
Fusion Energy
E457, Bldg. 81/1/C7
Station: 576-8261

GPL:rs

FIG. 1. MAXIMUM INDUCED EMF AND CURRENT IN COOLING WATER DUE TO MAGNETIC FIELDS

$$V = aE = BaV_m, \quad i = \frac{BaV_m}{t}$$

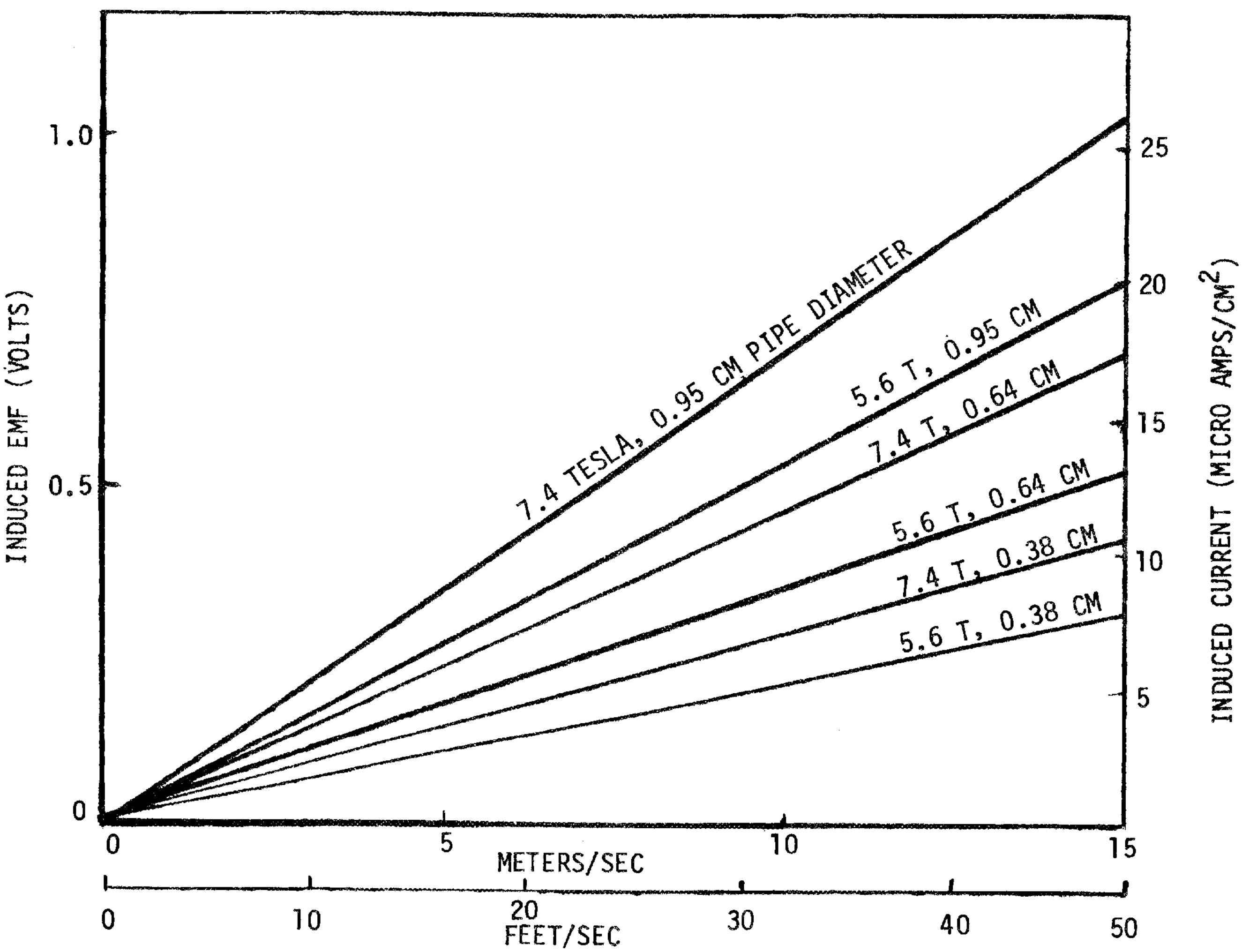
WHERE: V = INDUCED EMF (VOLTS)

i = INDUCED CURRENT DENSITY (AMPS/CM^2)

a = PIPE DIAMETER (CM)

V_m = COOLING FLUID VELOCITY (m/sec)

t = CONSTANT = ELECTROCHEMICAL POLARIZATION RESISTANCE (OHMS/m^2)



FLUID VELOCITY

PENETRATIONS CODE:

XYYZ-A
- SEQUENCE NO.
- LEVEL (1 OR 2)
- FUNCTION
- WALL(W) OR FLOOR(F)

FUNCTION CODE	EXPLANATION
BB	BUS BAR, MAGNET POWER SUPPLY
CR	CRYOGENICS
CT	CABLE TRAY
DM	DEMINERALIZED WATER
DP	DIAGNOSTIC PENETRATION
DW	DIAGNOSTIC WINDOW
MP	MAIN PORTAL
MW	MICROWAVE
PP	PERSONNEL PORTAL
VS	VACUUM SYSTEM

TABLE A

LOCATION	PENETRATION NO.	USE
NORTH WALL	WMW1-1 THRU WMW1-4	MICROWAVE
NORTH WALL	WVS1-2 THRU WVS1-4	VACUUM
NORTH WALL	WVS1-1 & WVS1-5	VACUUM
NORTH WALL	WCT1-1 THRU WCT1-9	CABLETRAY
NORTH WALL	WCT2-1 THRU WCT2-21	CABLETRAY
NORTH WALL	WDW2-1 THRU WDW2-3	DIAGNOSTICS
SOUTH WALL	WVS1-8 & WVS1-9	VACUUM
SOUTH WALL	WMW1-9 THRU WMW1-12	MICROWAVE
SOUTH WALL	WDM1-1	DEMINERALIZED WATER
SOUTH WALL	WDW2-6 THRU WDW2-8	DIAGNOSTICS
SOUTH WALL	WCR2-1 THRU WCR2-6	CRYOGENICS
LABYRINTH	WMW1-13	MICROWAVE
LEV 2 FLOOR	FDW2-1 THRU FDW2-11	DIAGNOSTICS
LEV 2 FLOOR	FVS2-1 THRU FVS2-15	VACUUM
LEV 2 FLOOR	FMW2-1 THRU FMW2-19	GYRO. WAVEGUIDE
LEV 2 FLOOR	FDP2-1 THRU FDP2-11	DIAGNOSTICS
LEV 2 FLOOR	FDM2-1	DEMINERALIZED WATER
LEV 2 FLOOR	FDM2-2	DEMINERALIZED WATER
LEV 2 FLOOR	FCR2-1	CRYOGENICS
EAST WALL	WVS1-6 & WVS1-7	VACUUM
EAST WALL	WCT2-22 THRU WCT2-25	CABLE TRAY
EAST WALL	WMW1-5 THRU WMW1-7	MICROWAVE
EAST WALL	WMW1-8	MICROWAVE
EAST WALL	WDW2-4 & WDW2-5	DIAGNOSTICS
EAST WALL	WPP1-1 & WPP2-1	PERSONNEL PORTAL
LABYRINTH	WBB2-1	MAGNET POWER SUPPLY
WEST WALL	WVS1-10 THRU WVS1-12	VACUUM
WEST WALL	WCT2-26 THRU WCT2-31	CABLE TRAY
WEST WALL	WMW1-14 THRU WMW1-16	MICROWAVE
WEST WALL	WDW2-9	DIAGNOSTICS
WEST WALL	WMP1-1 & WMP2-1	MAIN PORTAL

TABLE B

PENETRATION NO.	SLEEVE I.D.
WCR2-1 THRU WCR2-3	4.25
WCR2-4	5.25
WCR2-5	1.25
WCR2-6	4.25
WCT1-1 THRU WCT1-9	6.00
WVS1-1 THRU WVS1-3	8.25
WVS1-4 & WVS1-9	3.00
WVS1-6 & WVS1-12	3.00
WVS1-5	8.25
WVS1-7 & WVS1-8	8.25
WVS1-10 & WVS1-11	8.25
WCT2-1 THRU WCT2-31	6.00
WMW1-1 THRU WMW1-12	6.00
WMW1-14 THRU WMW1-16	6.00

8. TOLERANCES FOR DETAIL DIMENSIONS OF SLEEVES (SHEET 5) ARE: .X=±.1 AND .XX=±.03
7. PENETRATION VERTICALLY LOCATED 120 INCHES ABOVE LEVEL 1 FLOOR. SEE TABLE "B" FOR DIAMETER
6. SLEEVES MUST BE PROTECTED AGAINST CORROSION
5. ALL INTERNAL SURFACES MUST BE FREE OF BURRS, WELD MELT THRU, ETC. THAT MIGHT DAMAGE CABLE INSULATORS.
4. SUPPORT FOR X-RAY SHIELDING AT WALL PENETRATIONS WILL BE REQUIRED AND IS TBD
3. DIMENSION TAKEN FROM TOP OF LEVEL 2 FLOOR
2. TOLERANCES FOR CONCRETE & PENETRATION LOCATION DIMENSIONS ARE ±1 INCH UNLESS OTHERWISE NOTED
1. ALL DIMENSIONS IN INCHES

NOTES:

FILE:1056 708374001RE
VIEW/IMAGE:1/16
PLOT SCALE:.0104167
PLOT DATE:12 MAR'82

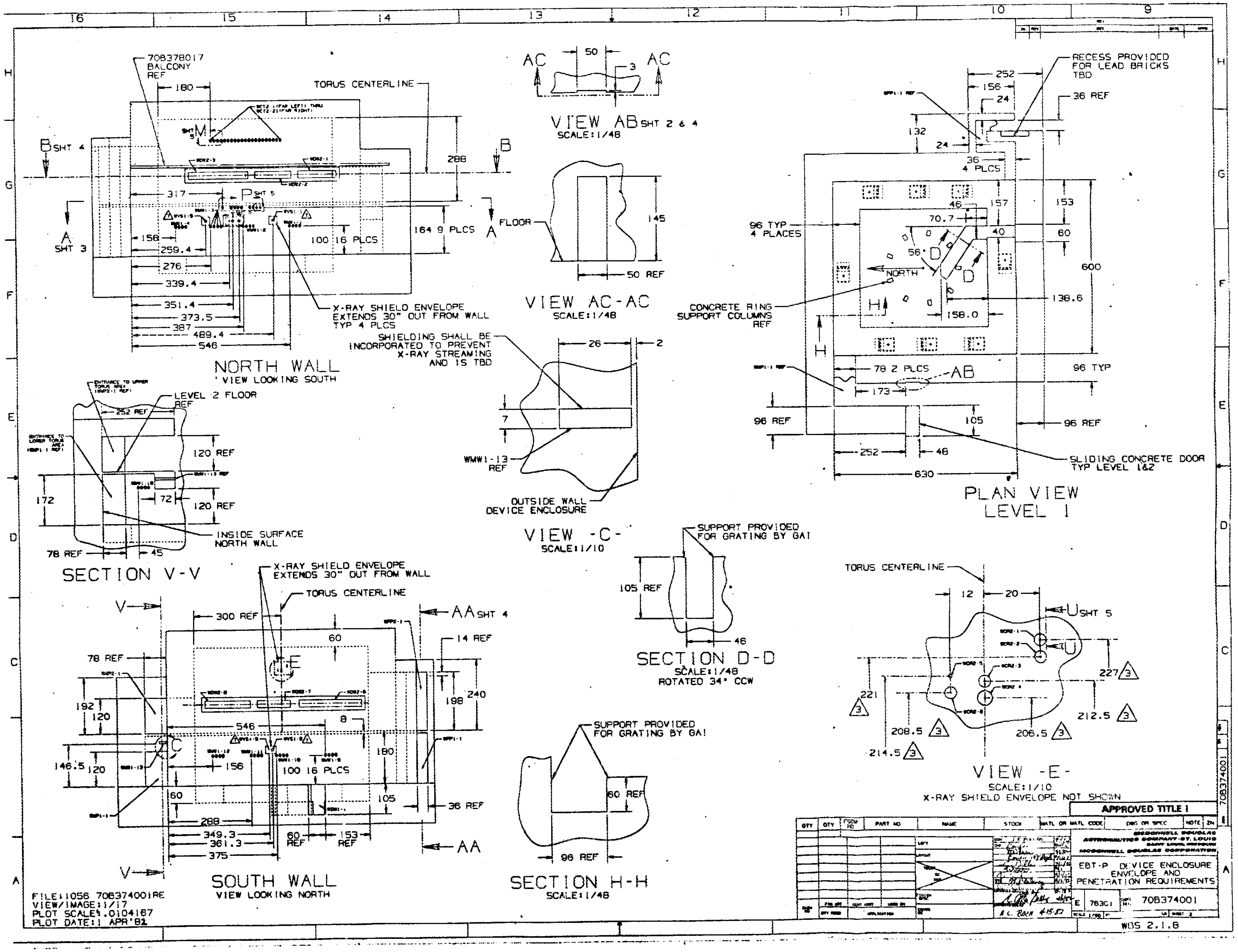
APPROVED TITLE I

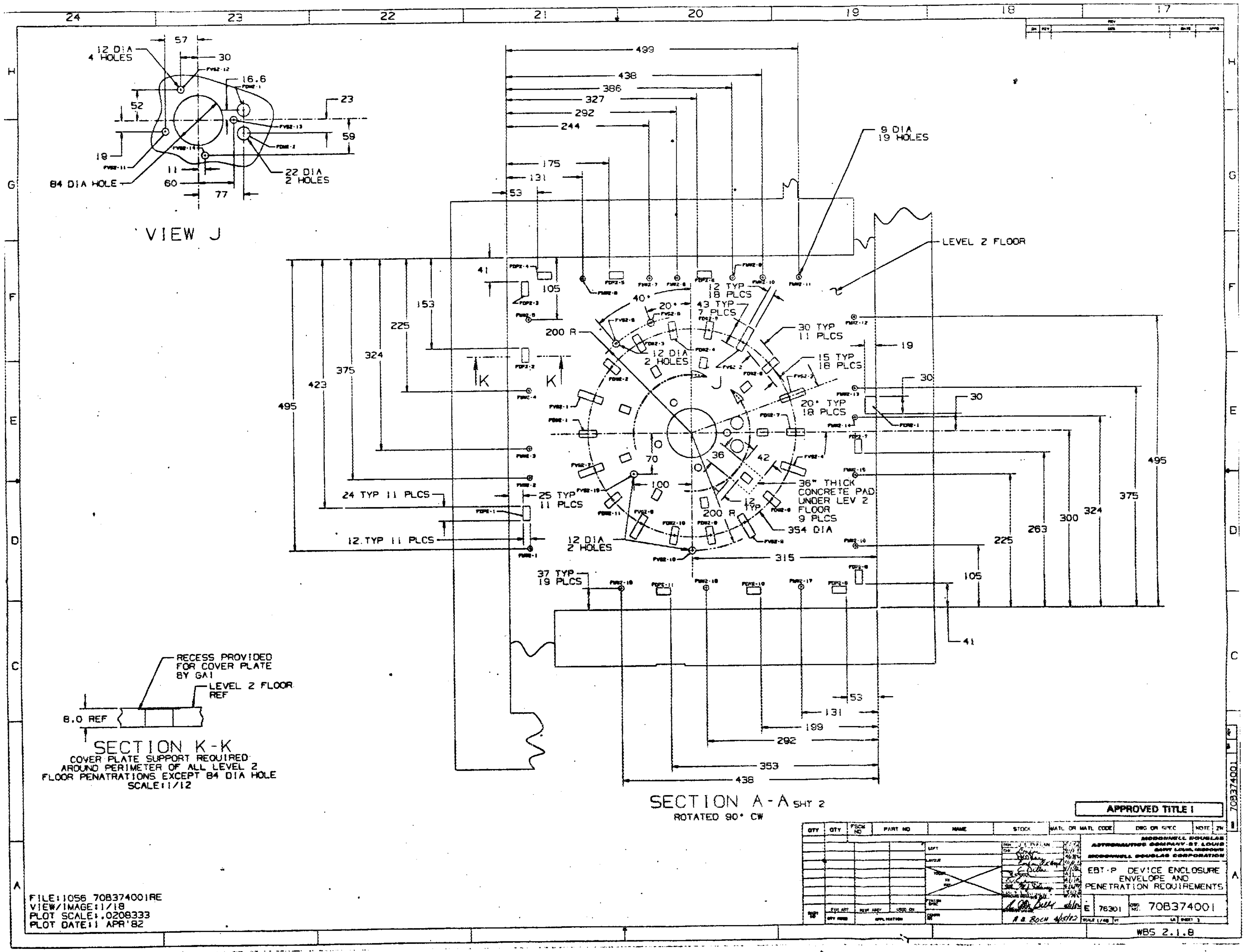
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-ST. LOUIS
MCDONNELL DOUGLAS CORPORATION

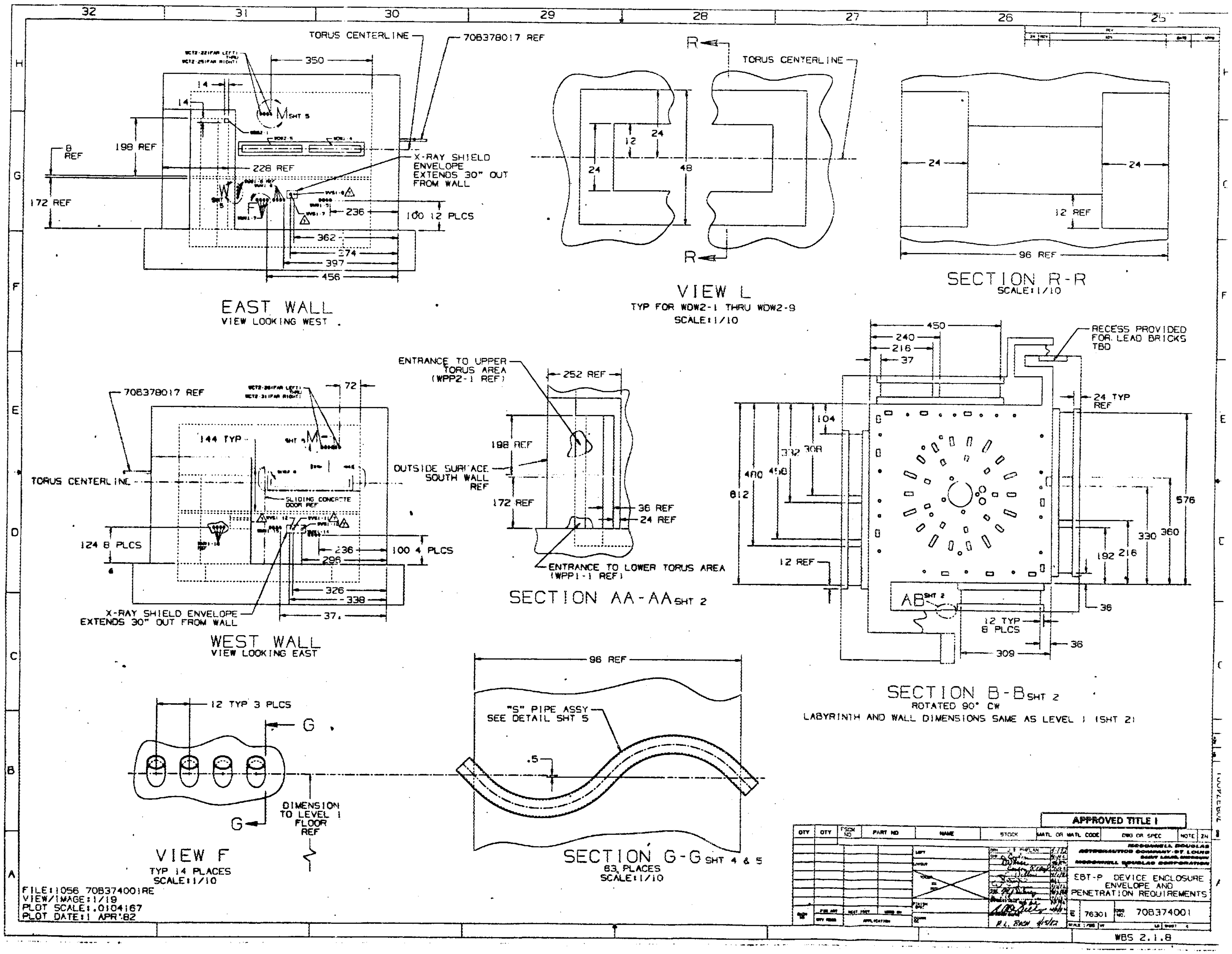
EBT-P DEVICE ENCLOSURE ENVELOPE AND PENETRATION REQUIREMENTS

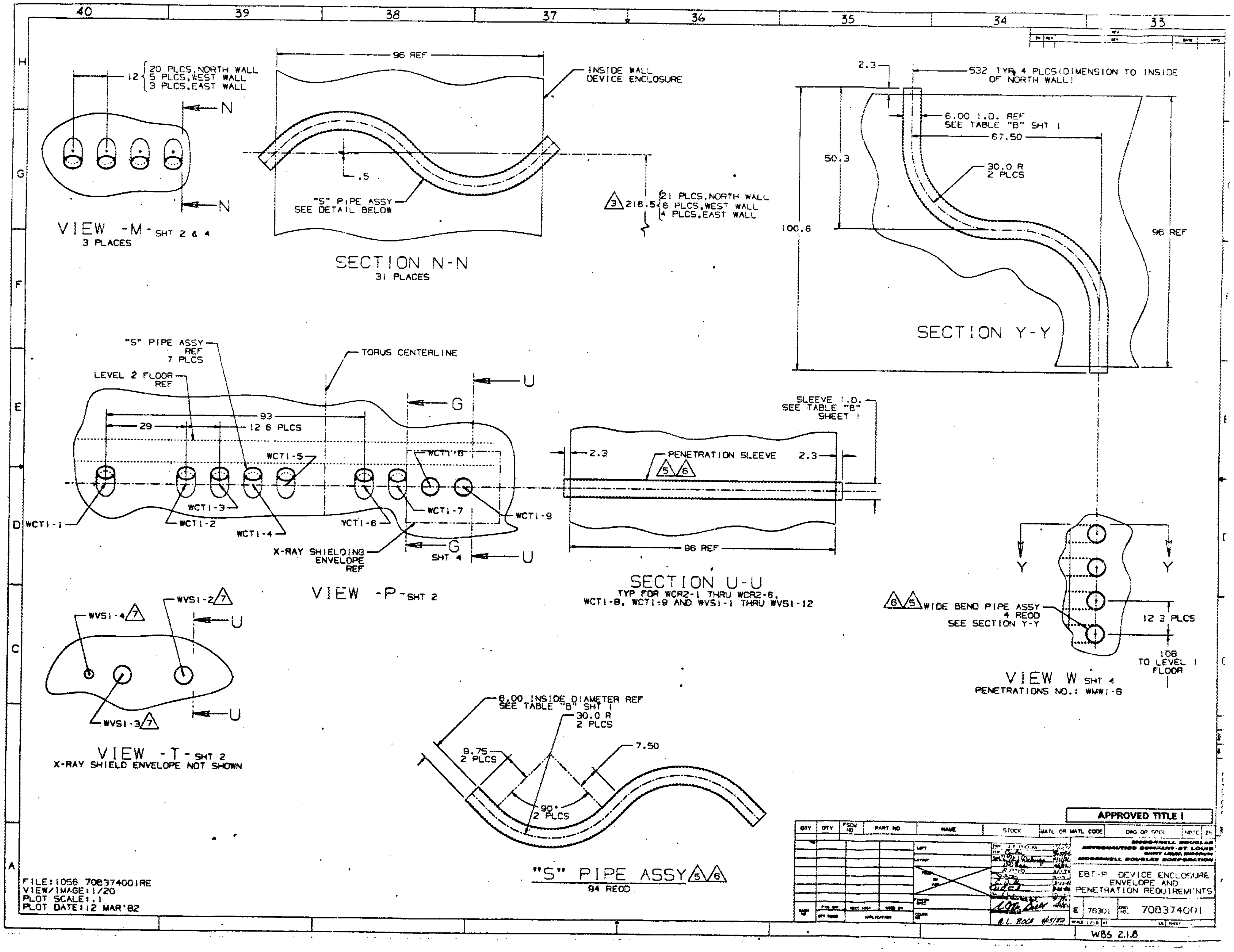
E 76301 708374001

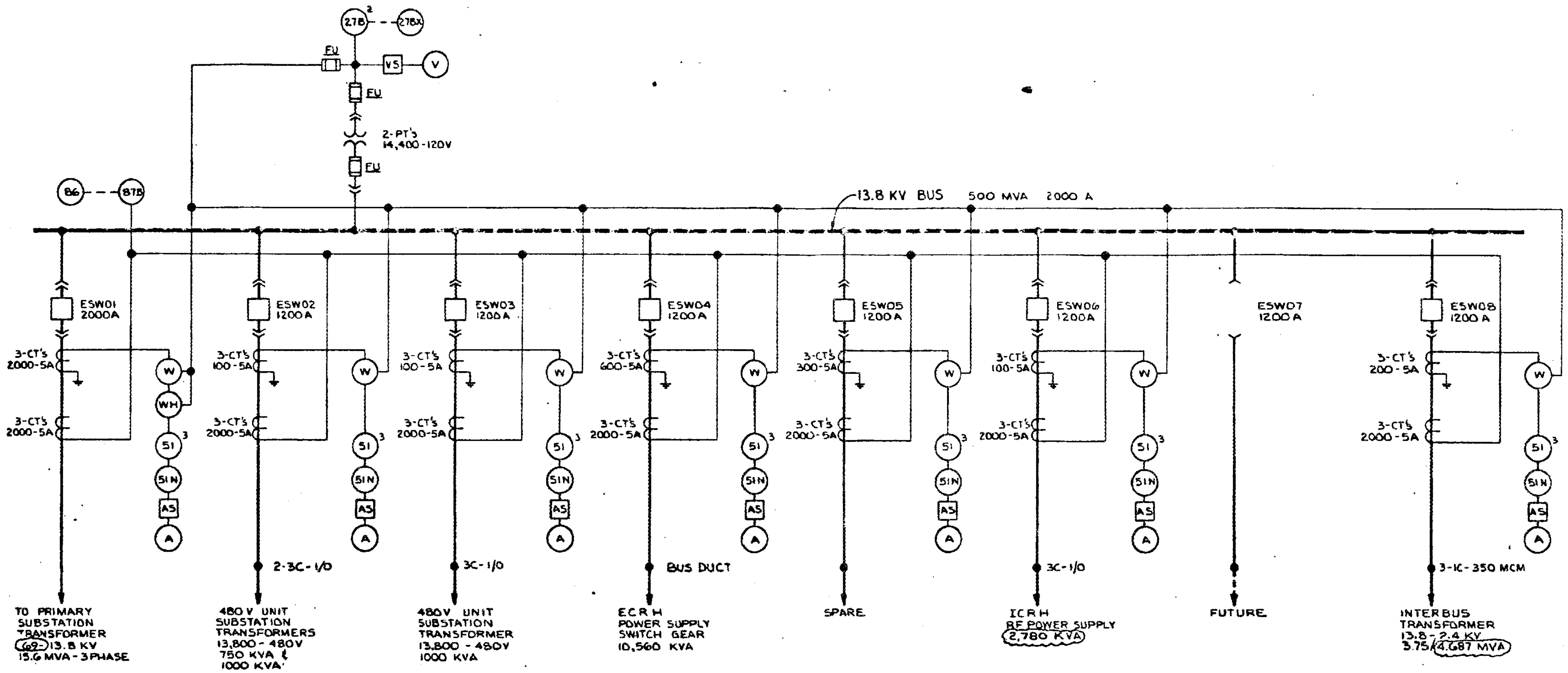
W85 2.1.8


NORTH WALL
VIEW LOOKING SOUTH
TORUS CENTERLINE
708378017 BALCONY REF
X-RAY SHIELD ENVELOPE EXTENDS 30" OUT FROM WALL TYP 4 PLCS
SHIELDING SHALL BE INCORPORATED TO PREVENT X-RAY STREAMING AND IS TBD
VIEW AB SHT 2 & 4
SCALE:1/48
VIEW AC-AC
SCALE:1/48
VIEW -C-
SCALE:1/10
OUTSIDE WALL DEVICE ENCLOSURE
PLAN VIEW
LEVEL 1
RECESS PROVIDED FOR LEAD BRICKS TBD
CONCRETE RING SUPPORT COLUMNS REF
SLIDING CONCRETE DOOR TYP LEVEL 1&2
SECTION V-V
LEVEL 2 FLOOR REF
INSIDE SURFACE NORTH WALL
SECTION D-D
SCALE:1/48
ROTATED 34° CCW
SUPPORT PROVIDED FOR GRATING BY GAI
VIEW -E-
SCALE:1/10
X-RAY SHIELD ENVELOPE NOT SHOWN
SOUTH WALL
VIEW LOOKING NORTH
SECTION H-H
SCALE:1/48
FILE:1056 708374001RE
VIEW/IMAGE:1/17
PLOT SCALE:.0104167
PLOT DATE:1 APR'82
APPROVED TITLE I
McDONNELL DOUGLAS CORPORATION
EBT-P DEVICE ENCLOSURE ENVELOPE AND PENETRATION REQUIREMENTS
708374001
WBS 2.1.8


VIEW J
12 DIA 4 HOLES
84 DIA HOLE
22 DIA 2 HOLES
SECTION K-K
COVER PLATE SUPPORT REQUIRED AROUND PERIMETER OF ALL LEVEL 2 FLOOR PENATRATIONS EXCEPT 84 DIA HOLE
SCALE: 1/12
RECESS PROVIDED FOR COVER PLATE BY GAI
LEVEL 2 FLOOR REF
8.0 REF
9 DIA 19 HOLES
LEVEL 2 FLOOR
36" THICK CONCRETE PAD UNDER LEV 2 FLOOR 9 PLCS
354 DIA
SECTION A-A SHT 2
ROTATED 90° CW
FILE: 1056 708374001RE
VIEW/IMAGE: 1/18
PLOT SCALE: .0208333
PLOT DATE: 1 APR '82
APPROVED TITLE I
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-ST. LOUIS
EBT-P DEVICE ENCLOSURE ENVELOPE AND PENETRATION REQUIREMENTS
E 76301 708374001
WBS 2.1.8


TORUS CENTERLINE
708378017 REF
350
198 REF
228 REF
172 REF
X-RAY SHIELD ENVELOPE EXTENDS 30" OUT FROM WALL
236
100 12 PLCS
362
374
397
456
EAST WALL
VIEW LOOKING WEST
VIEW L
TYP FOR WDW2-1 THRU WDW2-9
SCALE:1/10
SECTION R-R
SCALE:1/10
96 REF
12 REF
ENTRANCE TO UPPER TORUS AREA (WPP2-1 REF)
252 REF
OUTSIDE SURFACE SOUTH WALL REF
36 REF
24 REF
ENTRANCE TO LOWER TORUS AREA (WPP1-1 REF)
SECTION AA-AA SHT 2
TORUS CENTERLINE
SLIDING CONCRETE DOOR REF
124 8 PLCS
100 4 PLCS
X-RAY SHIELD ENVELOPE EXTENDS 30" OUT FROM WALL
WEST WALL
VIEW LOOKING EAST
RECESS PROVIDED FOR LEAD BRICKS TBD
24 TYP REF
12 TYP 8 PLCS
SECTION B-B SHT 2
ROTATED 90° CW
LABYRINTH AND WALL DIMENSIONS SAME AS LEVEL 1 (SHT 2)
12 TYP 3 PLCS
DIMENSION TO LEVEL 1 FLOOR REF
VIEW F
TYP 14 PLACES
SCALE:1/10
"S" PIPE ASSY SEE DETAIL SHT 5
SECTION G-G SHT 4 & 5
83 PLACES
SCALE:1/10
APPROVED TITLE I
EBT-P DEVICE ENCLOSURE ENVELOPE AND PENETRATION REQUIREMENTS
76301
708374001
WBS 2.1.8
FILE:1056 708374001RE
VIEW/IMAGE:1/19
PLOT SCALE:.0104167
PLOT DATE:1 APR'82


VIEW -M- SHT 2 & 4
3 PLACES
20 PLCS, NORTH WALL
5 PLCS, WEST WALL
3 PLCS, EAST WALL
96 REF
INSIDE WALL
DEVICE ENCLOSURE
"S" PIPE ASSY
SEE DETAIL BELOW
SECTION N-N
31 PLACES
216.5
21 PLCS, NORTH WALL
6 PLCS, WEST WALL
4 PLCS, EAST WALL
532 TYP, 4 PLCS (DIMENSION TO INSIDE OF NORTH WALL)
6.00 I.D. REF
SEE TABLE "B" SHT 1
67.50
30.0 R
2 PLCS
50.3
100.6
96 REF
SECTION Y-Y
"S" PIPE ASSY
REF
7 PLCS
TORUS CENTERLINE
LEVEL 2 FLOOR
REF
93
12 6 PLCS
29
WCT1-1
WCT1-2
WCT1-3
WCT1-4
WCT1-5
WCT1-6
WCT1-7
WCT1-8
WCT1-9
X-RAY SHIELDING
ENVELOPE
REF
SHT 4
VIEW -P- SHT 2
SLEEVE I.D.
SEE TABLE "B"
SHEET 1
PENETRATION SLEEVE
2.3
96 REF
SECTION U-U
TYP FOR WCR2-1 THRU WCR2-6, WCT1-8, WCT1-9 AND WVS1-1 THRU WVS1-12
WIDE BEND PIPE ASSY
4 REQD
SEE SECTION Y-Y
12 3 PLCS
108
TO LEVEL 1
FLOOR
VIEW W SHT 4
PENETRATIONS NO.: WMW1-8
WVS1-2
WVS1-3
WVS1-4
VIEW -T- SHT 2
X-RAY SHIELD ENVELOPE NOT SHOWN
6.00 INSIDE DIAMETER REF
SEE TABLE "B" SHT 1
30.0 R
2 PLCS
9.75
2 PLCS
7.50
90°
2 PLCS
"S" PIPE ASSY
94 REQD
APPROVED TITLE I
EBT-P DEVICE ENCLOSURE
ENVELOPE AND
PENETRATION REQUIREMENTS
76301
708374001
WBS 2.1.8
FILE: 1056 708374001RE
VIEW/IMAGE: 1/20
PLOT SCALE: 1
PLOT DATE: 12 MAR '82



LEGEND

SYMBOL	DESCRIPTION
(A)	AMMETER
(V)	VOLTMETER
(W)	WATTMETER
(WH)	KILOWATTHOUR METER
( )	PROTECTIVE RELAY
[AS]	AMMETER SWITCH
[VS]	VOLTMETER SWITCH

RELAY SCHEDULE

DEVICE NO.	TYPE	FUNCTION
27 B		UNDERVOLTAGE
51		TIME DELAY OVERCURRENT
51 N		TIME DELAY GROUND OVERCURRENT
86		LOCKOUT
87 B		BUS. DIFFERENTIAL

¼" = 1'-0" 0' 5' 10' 15' 20'

APPROVED TITLE I

REV	MADE	CHKD	SQ LD	APP	DATE

REVISIONS

STATUS OF DRAWING	DEFINITION
☐ APPROVED	REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
☒ PRELIMINARY	REPRESENTS ACCEPTABLE DESIGN CONCEPTS. SUBJECT TO CHANGE WITHOUT NOTICE.
☐ CONCEPTUAL	REPRESENTS GENERAL CONCEPTS BASED ON UNSUBSTANTIATED ASSUMPTIONS. GROSS CHANGES COULD ENSUE WITHOUT NOTICE.

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
ELMO BUMPY TORUS (EBT-P) PROJECT
PROOF OF PRINCIPLE
ELECTRICAL
ONE LINE DIAGRAM
13.8 KV SWITCHGEAR

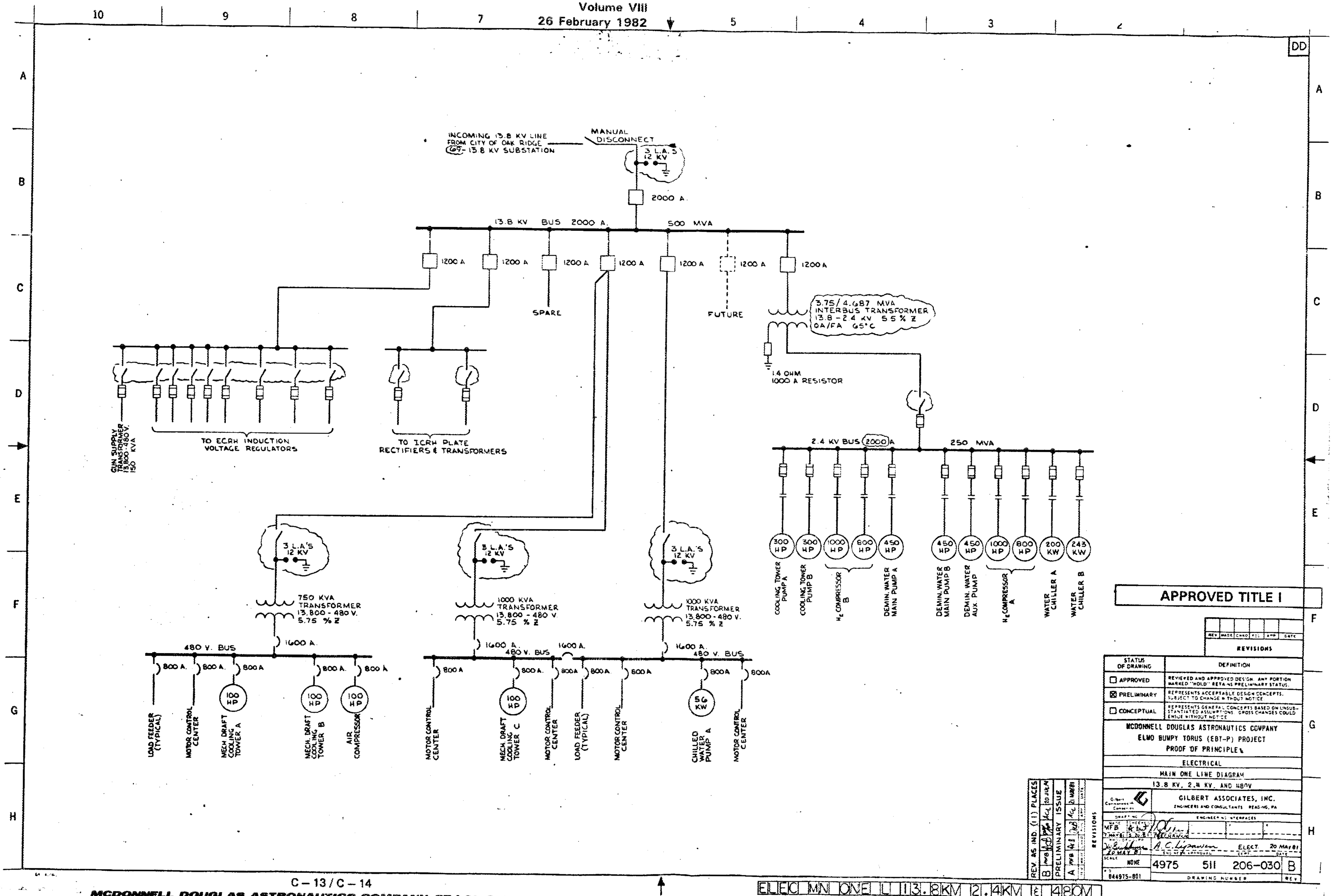
REV		MADE	CHKD	SQ LD	APP	DATE
B	REV. AS IND (3) PLACES.	KB			ACL	20 JUL 81
A	PRELIMINARY ISSUE				ACL	21 MAY 81

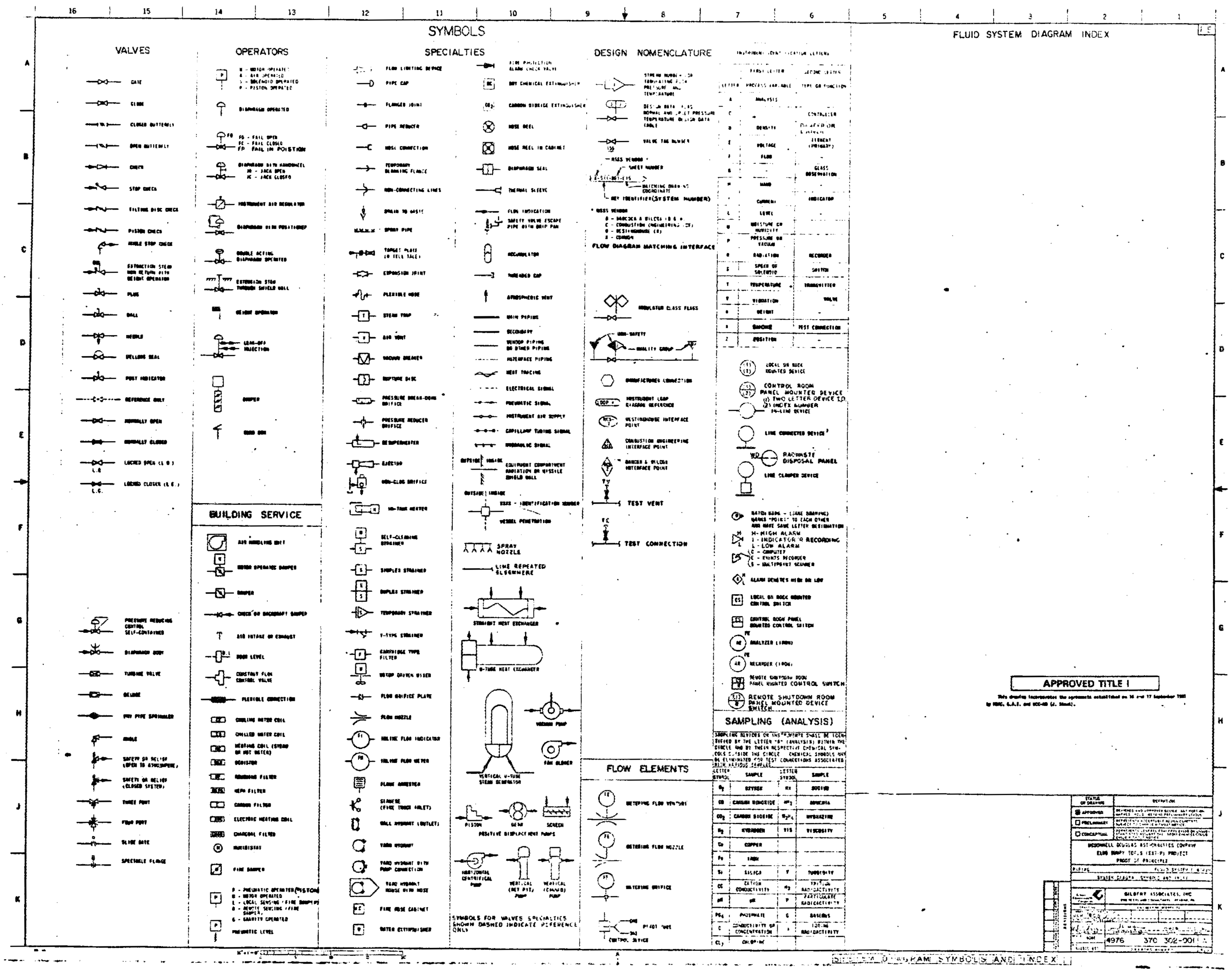
REVISIONS

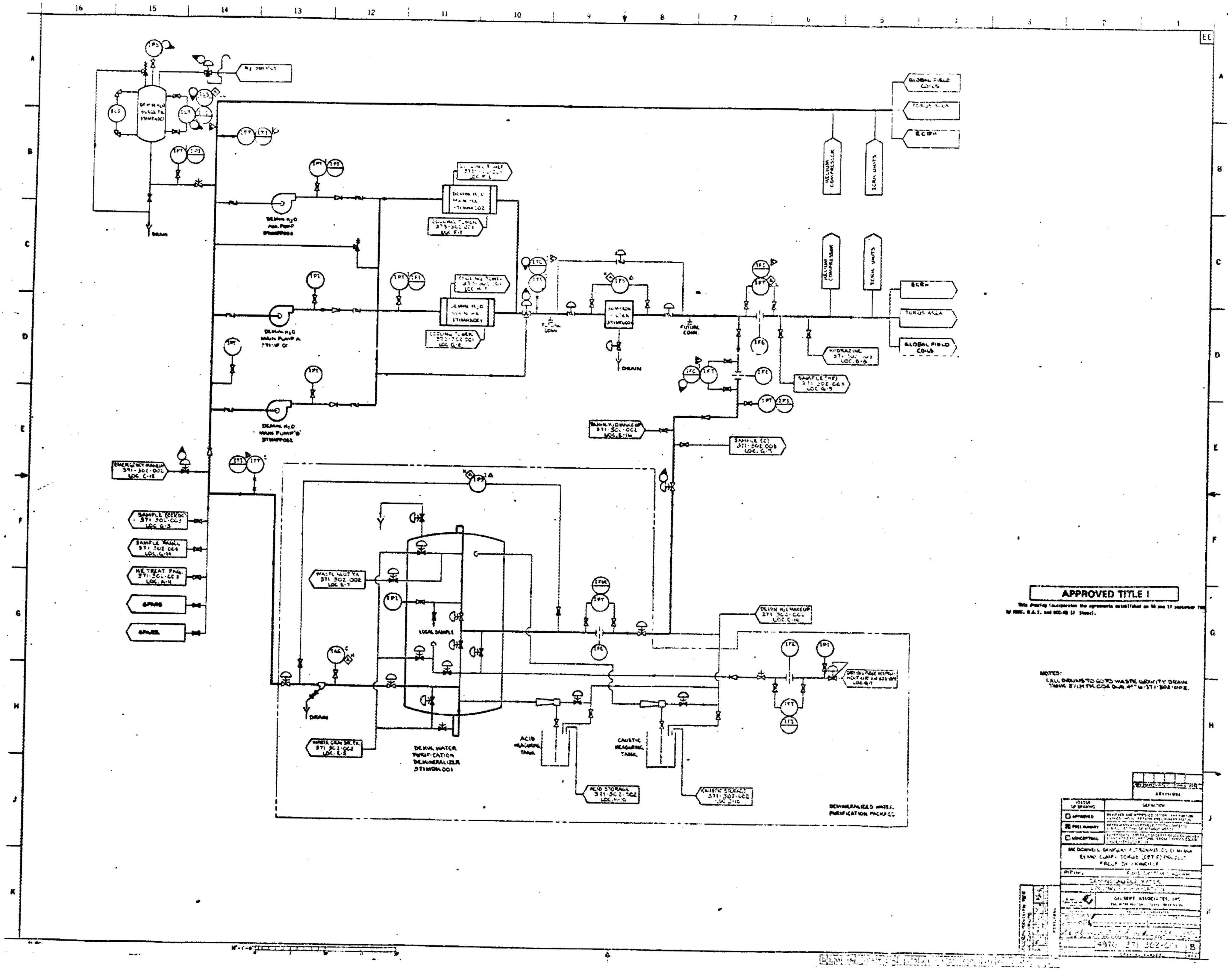
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS READING, PA

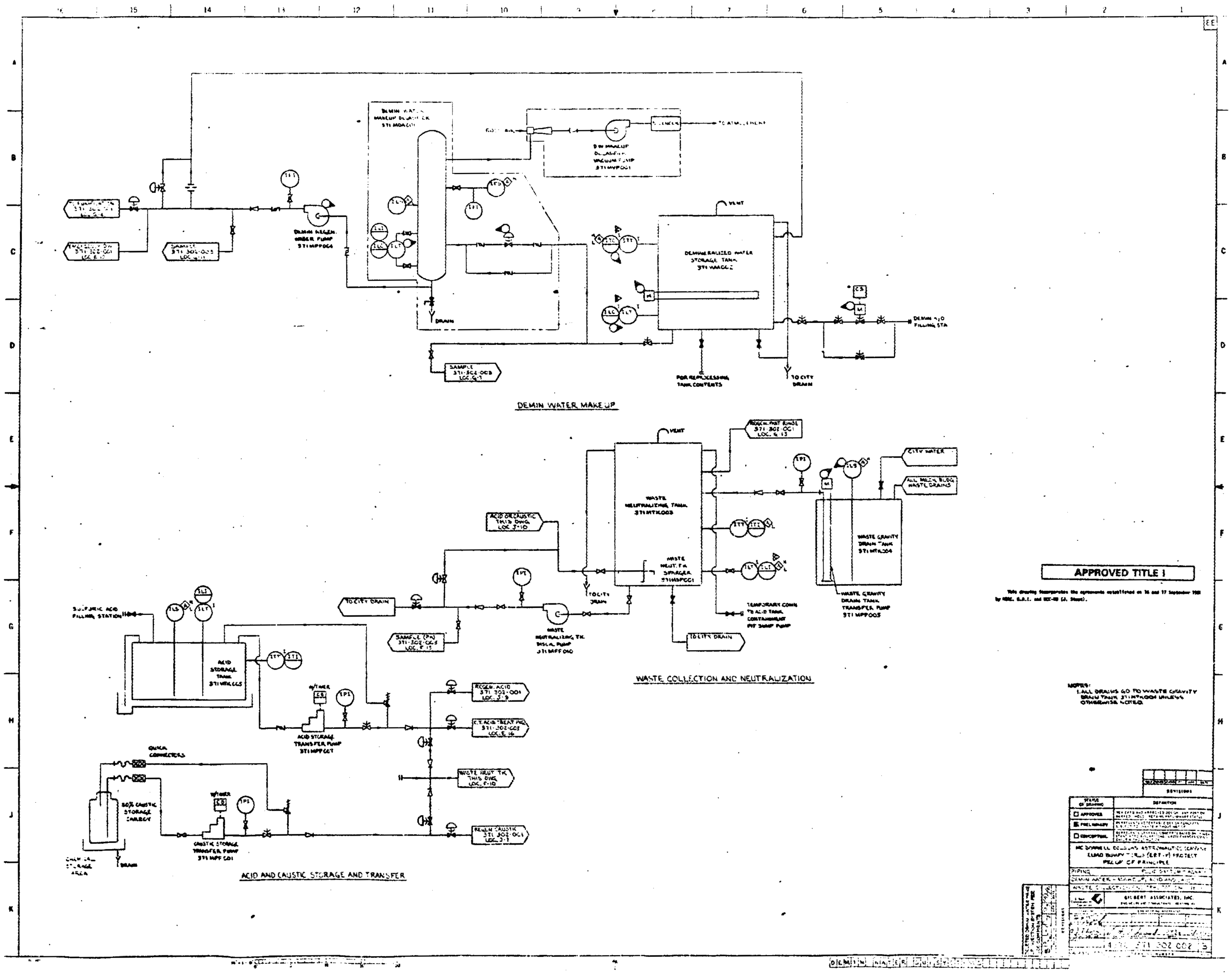
DRAFTING — MADE KDH 3-25-81 — MECHANICAL
ENGINEERING INTERFACES
21 MAY 81 — A.C. Lejawen — ELECT — 20 MAY 81
ENG'G APPROVAL — DEPT. — DATE
SCALE NONE
4975 511 206-001 B
DRAWING NUMBER — REV
044975-001

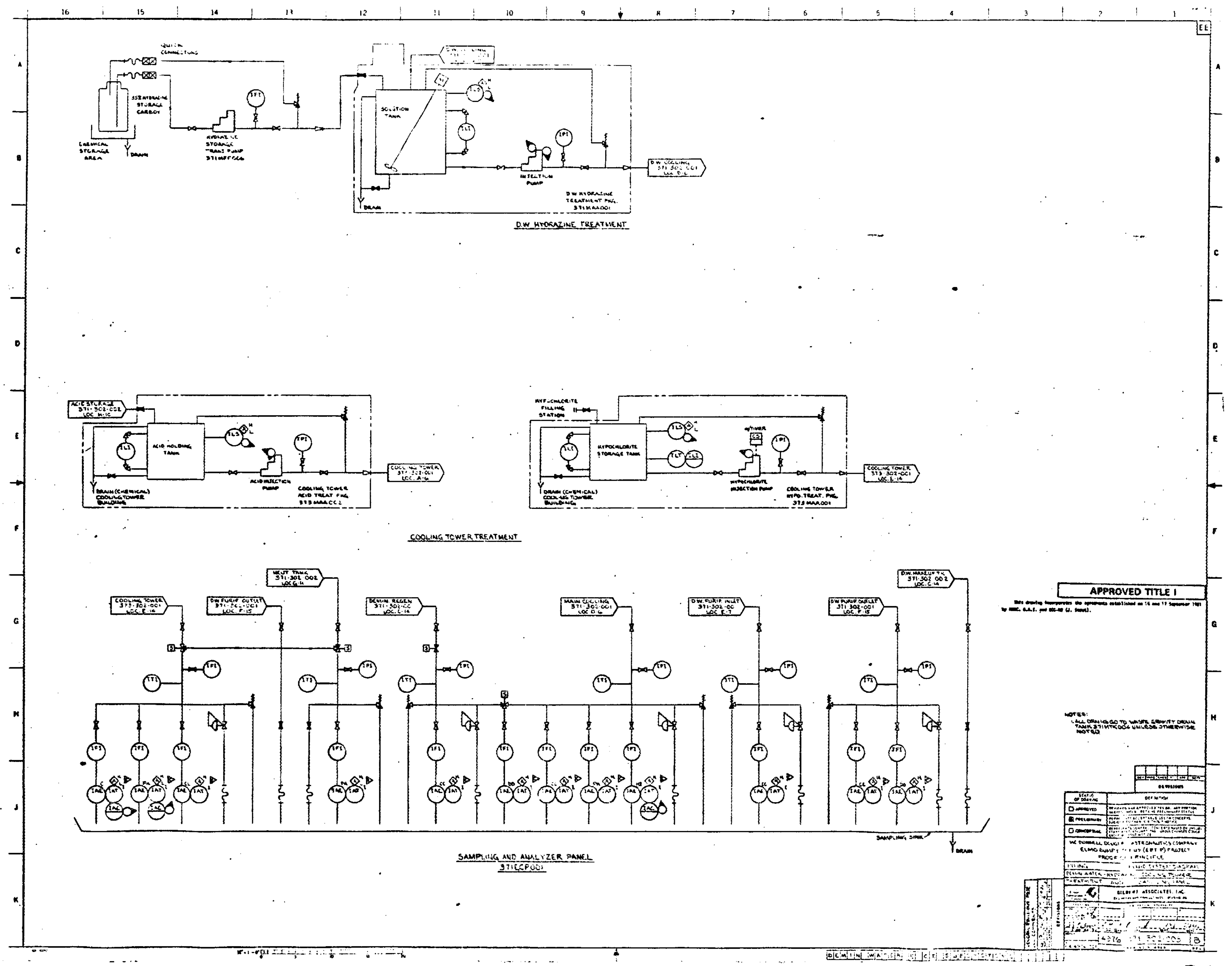
ELEC ONE LINE DIAG 13.8 KV SWGR

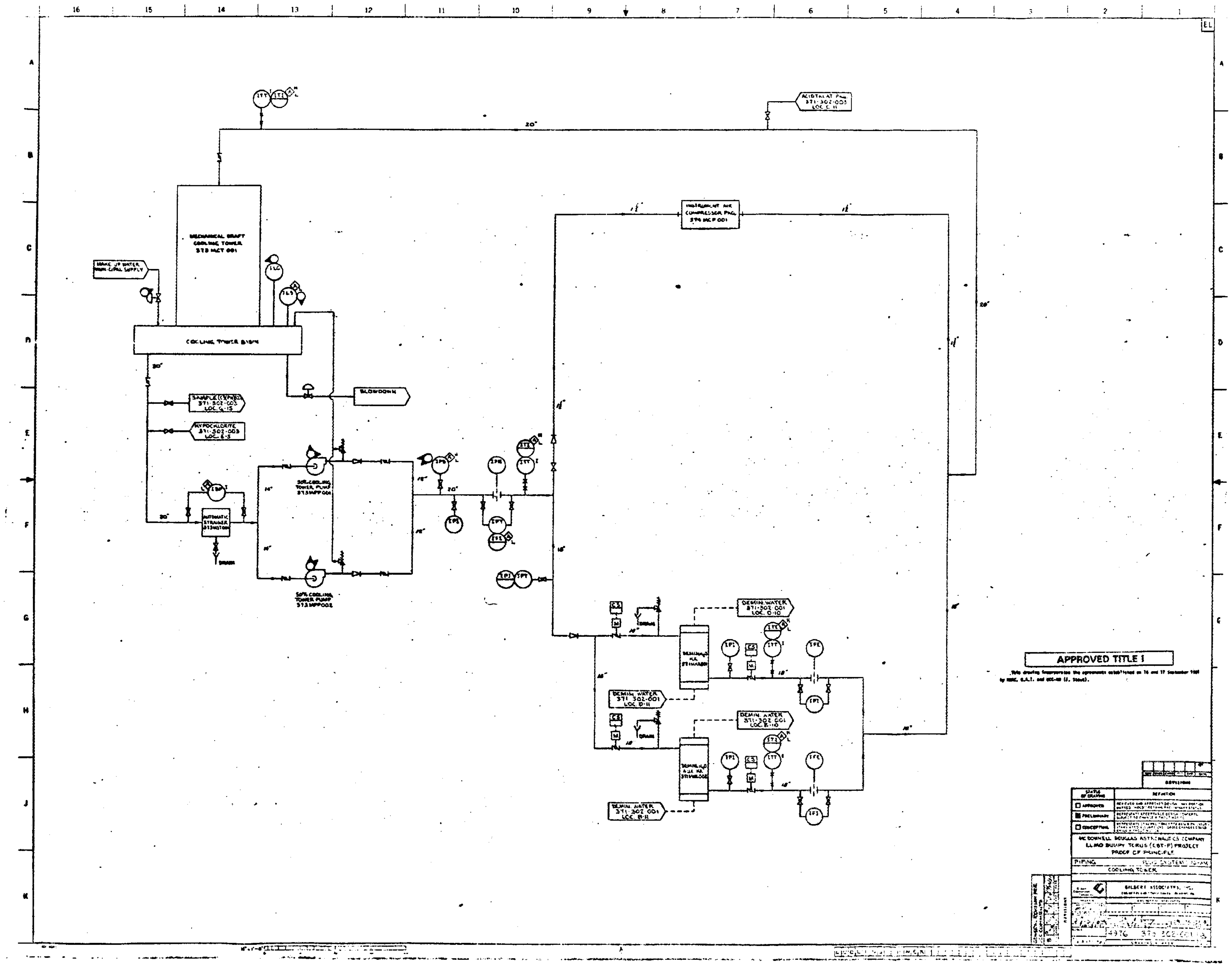

INCOMING 13.8 KV LINE FROM CITY OF OAK RIDGE 69 - 13.8 KV SUBSTATION
MANUAL DISCONNECT
3 L.A.'S 12 KV
2000 A.
13.8 KV BUS 2000 A.
500 MVA
1200 A
SPARE
FUTURE
3.75/4.687 MVA INTERBUS TRANSFORMER 13.8 - 2.4 KV 5.5 % Z OA/FA 65°C
1.4 OHM 1000 A RESISTOR
GUN SUPPLY TRANSFORMER 13,800 - 480 V. 150 KVA
TO ECRH INDUCTION VOLTAGE REGULATORS
TO ECRH PLATE RECTIFIERS & TRANSFORMERS
2.4 KV BUS 2000 A
250 MVA
300 HP
1000 HP
800 HP
450 HP
200 KW
243 KW
COOLING TOWER PUMP A
COOLING TOWER PUMP B
H_e COMPRESSOR B
DEMIN. WATER MAIN PUMP A
DEMIN. WATER MAIN PUMP B
DEMIN. WATER AUX PUMP
H_e COMPRESSOR A
WATER CHILLER A
WATER CHILLER B
750 KVA TRANSFORMER 13,800 - 480 V. 5.75 % Z
1000 KVA TRANSFORMER 13,800 - 480 V. 5.75 % Z
1600 A.
480 V. BUS
800 A.
100 HP
56 KW
LOAD FEEDER (TYPICAL)
MOTOR CONTROL CENTER
MECH DRAFT COOLING TOWER A
MECH. DRAFT COOLING TOWER B
AIR COMPRESSOR
MECH DRAFT COOLING TOWER C
CHILLED WATER PUMP A
APPROVED TITLE I
REVISIONS
STATUS OF DRAWING
DEFINITION
APPROVED
REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
PRELIMINARY
REPRESENTS ACCEPTABLE DESIGN CONCEPTS. SUBJECT TO CHANGE WITHOUT NOTICE.
CONCEPTUAL
REPRESENTS GENERAL CONCEPTS BASED ON UNSUBSTANTIATED ASSUMPTIONS. GROSS CHANGES COULD ENSUE WITHOUT NOTICE
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
ELMO BUMPY TORUS (EBT-P) PROJECT
PROOF OF PRINCIPLE
ELECTRICAL
MAIN ONE LINE DIAGRAM
13.8 KV, 2.4 KV, AND 480V
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS READING, PA
REV. AS IND. (11) PLACES
PRELIMINARY ISSUE
ELECT.
20 MAY 81
SCALE NONE
044975-801
4975 511 206-030 B
DRAWING NUMBER
ELEC MN ONE L 13.8KV 2.4KV & 480V

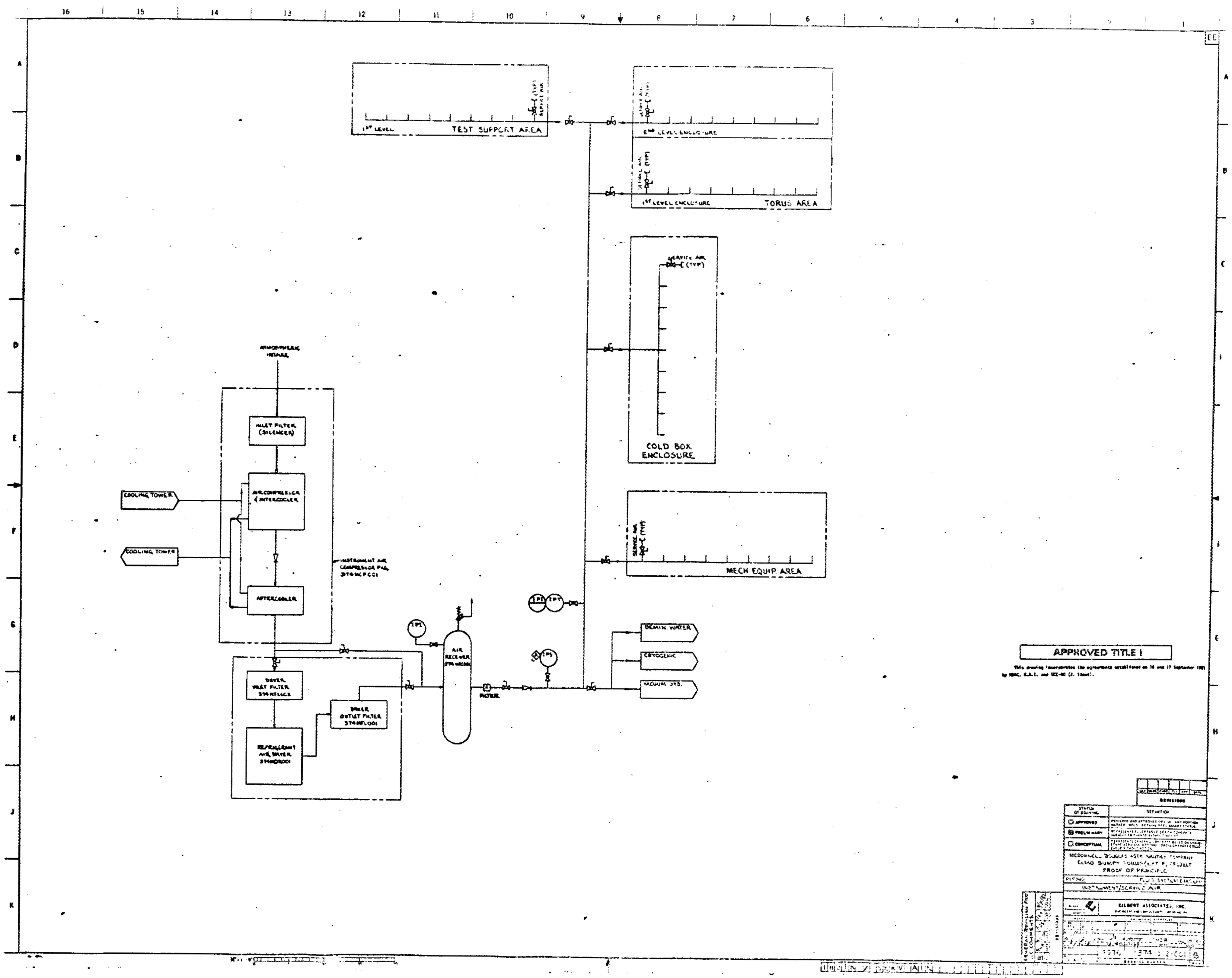

SYMBOLS
VALVES
OPERATORS
SPECIALTIES
DESIGN NOMENCLATURE
BUILDING SERVICE
FLOW ELEMENTS
SAMPLING (ANALYSIS)
FLUID SYSTEM DIAGRAM INDEX
APPROVED TITLE I
TEST VENT
TEST CONNECTION

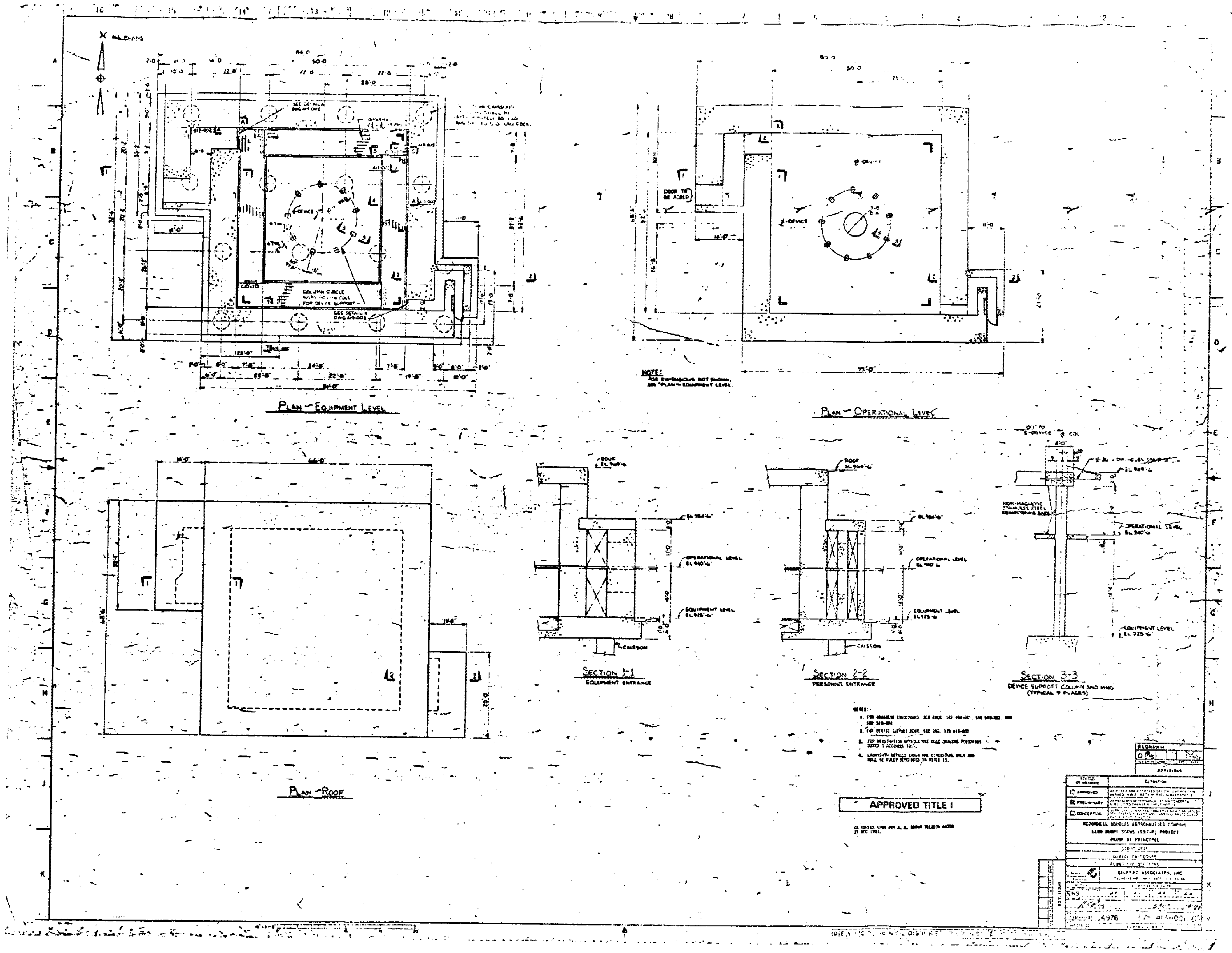

APPROVED TITLE I
DRAIN
GLOBAL FIELD COILS
TORUS AREA
ECRH
DEMIN. WATER PURIFICATION DEMINERALIZER
ACID MEASURING TANK
CAUSTIC MEASURING TANK
DEMINERALIZED WATER PURIFICATION PACKAGE
SPARE
SPARE
LOCAL SAMPLE
FUTURE CONN.

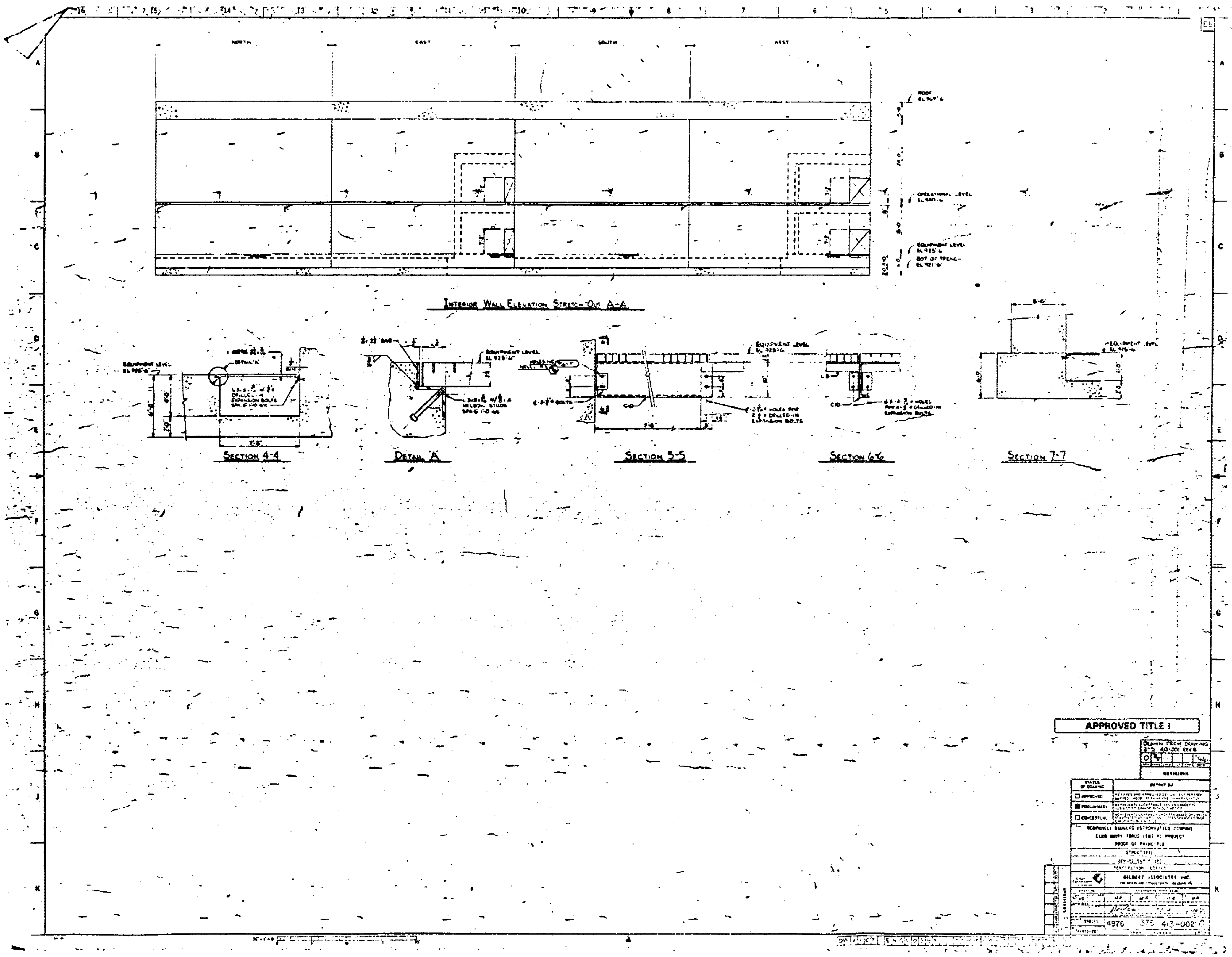

DEMIN WATER MAKE UP
WASTE COLLECTION AND NEUTRALIZATION
ACID AND CAUSTIC STORAGE AND TRANSFER
APPROVED TITLE I


D.W. HYDRAZINE TREATMENT
COOLING TOWER TREATMENT
SAMPLING AND ANALYZER PANEL
APPROVED TITLE I


BLOWDOWN
APPROVED TITLE I


TEST SUPPORT AREA
1ST LEVEL
2ND LEVEL ENCLOSURE
1ST LEVEL ENCLOSURE
TORUS AREA
SERVICE AIR (TYP)
COLD BOX ENCLOSURE
MECH EQUIP AREA
ATMOSPHERIC INTAKE
INLET FILTER (SILENCER)
AIR COMPRESSOR & INTERCOOLER
COOLING TOWER
COOLING TOWER
AFTERCOOLER
INSTRUMENT AIR COMPRESSOR PKG.
AIR RECEIVER
FILTER
DEMIN. WATER
CRYOGENIC
VACUUM SYS.
DRYER INLET FILTER
DRYER OUTLET FILTER
REFRIGERANT AIR DRYER
APPROVED TITLE I
GILBERT ASSOCIATES, INC.
INSTRUMENT/SERVICE AIR
PROOF OF PRINCIPLE


PLAN – EQUIPMENT LEVEL
PLAN – OPERATIONAL LEVEL
PLAN – ROOF
SECTION 1-1
EQUIPMENT ENTRANCE
SECTION 2-2
PERSONNEL ENTRANCE
SECTION 3-3
DEVICE SUPPORT COLUMN AND RING
(TYPICAL 9 PLACES)
APPROVED TITLE I
OPERATIONAL LEVEL
EQUIPMENT LEVEL
CAISSON
ROOF


NORTH
EAST
SOUTH
WEST
INTERIOR WALL ELEVATION STRETCH-OUT A-A
SECTION 4-4
DETAIL 'A'
SECTION 5-5
SECTION 6-6
SECTION 7-7
APPROVED TITLE I
4976
375
413-002